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ASSESSMENT OF CURRENT U.S. DEPARTMENT OF TRANSPORTATION FIRE SAFETY EFFORTS

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Cambridge MA 02142

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FINAL REPORT

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The Urban Mass Transportation Administration (UMTA), has undertaken the task of assessing the entire area of fire research to determine how to provide means to reduce the fire threat in transit systems, and thus, to provide a safer means of transportation for the traveling and commuting public. This report presents the results of that assessment by the Transportation Systems Center (TSC). The study identifies and recommends suitable remedial actions and reflects the present state of transportation fire safety efforts. Emphasis has been placed on Federal Government efforts, and particularly those by the Department of Transportation (DOT). Although the assigned task is directed at fire safety in transit systems, the assessment encompasses all transportation-related fire safety. The intent of this approach has been to emphasize the similarities which exist among the problems and in the programs of the modes. In many instances, the programs of one mode will benefit one or more of the other modes.

In conducting this assessment, TSC has reviewed and incorporated into this report the pertinent information resulting from the following efforts: 1) a search and review of public and private sector programs; 2) identification and review of existing data banks (materials and accident statistics); and 3) identification and review of existing regulations, standards, specifications, and guidelines. Each of these efforts is discussed in detail in the report, and where necessary, in Appendix A: Bibliography of Fire Safety Literature and Appendix B: Survey of DOT Fire Safety Products.

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16. Abstract

This report presents the results of an assessment of current fire safety efforts related to transportation. Emphasis has been placed on Federal Government efforts, particularly those by the U.S. Department of Transportation.

In conducting this assessment, TSC has reviewed and incorporated into this report the pertinent information resulting form the following efforts:

- o A Search and Review of Public and Private Sector Programs,
- o Identification and Review of Existing Data Banks (Materials and Accident Statistics),
- o Identification and Review of Existing Regulations, Standards, Specifications, and Guidelines.

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PREFACE

The Urban Mass Transportation Administration (UMTA), in its role of overviewing modes of transportation that move millions of passengers daily, has undertaken the task of assessing the hazards and risks involving these operations. Concomitantly, it is looking into the entire area of fire research to determine how to use this tremendous body of work to provide means to reduce the fire threat, and thus, provide safer means of transportation for the traveling and commuting public.

This present document, "Assessment of Current U.S. Department of Transportation Fire Safety Efforts," represents one of the series of tasks commissioned by UMTA to obtain the broadest overview of the current status of the entire problem. It is anticipated that this study will lead to a considerable reduction in the threat to human life and loss of property caused by fire.

The authors wish to thank William J. Rhine and Robert I. Haught, UMTA, for their valuable guidance and comments on this study. They also wish to acknowledge the support and contributions from the following individuals: Herbert L. Bogen, Raytheon Service Company (RSC), in preparing section 4; Regina Clifton, RSC, in preparing appendix A; and A.E. Barrington and C.E. Bogner, Transportation Systems Center, for their comments on the final draft of the report.

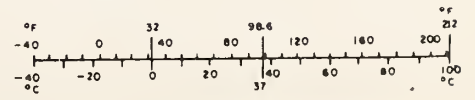
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	qwerts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	litres	2.1	pints	pt
l	litres	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. INTRODUCTION

The Transportation Systems Center (TSC) has been asked by the Urban Mass Transportation Administration (UMTA) to assess the overall fire threat in transit systems and to identify and recommend suitable remedial actions. This report presents an assessment of current fire safety efforts. Emphasis has been placed on Federal Government efforts, particularly those by the Department of Transportation (DOT). Although the assigned task is directed at fire safety in transit systems, the assessment encompasses all transportation-related fire safety. The intent of this approach has been to emphasize the commonalities which exist among the problems and in the programs of the modes. In many instances the programs of one mode will benefit one or more other modes.

In conducting this assessment, TSC has reviewed and incorporated into this report the pertinent information resulting from the following efforts:

- o A Search and Review of Public and Private Sector Programs.
- o Identification and Review of Existing Data Banks (Materials and Accident Statistics).
- o Identification and Review of Existing Regulations, Standards, Specifications, and Guidelines.

Each of the above is discussed in detail in the following sections and, where necessary, in the two appendices. It is the intent of this report to reflect the present state of transportation fire safety.

2. LITERATURE SEARCH

The literature search has been directed at identifying all the pertinent fire safety literature published since 1970. Sources utilized in this search included the Transportation Research Information Service (TRIS), the National Technical Information Service (NTIS), the Engineering Index Monthly (COMPENDEX), the Massachusetts Institute of Technology (MIT) Library, the Smithsonian Science Information Exchange (SSIE) and the Transportation Systems Center (TSC) Files. In each instance a thorough search was conducted to identify the available fire safety literature and ascertain its applicability to the present project. Although this project is directed at transit system fires, the key words employed in the search were of a more general nature. A broad range of key words was used in order to identify all literature pertaining to transportation system fires. The bibliography resulting from this literature search is contained in Appendix A.

The following sections contain a brief description of each of the sources utilized and the key words employed in each search. Differences in the key words used in each search were required due to the nature of the source. Retrieval words appropriate for one source often would retrieve material unrelated to transportation when used with another source.

2.1 TRANSPORTATION RESEARCH INFORMATION SERVICE (TRIS)

The TRIS network is sponsored by the Department of Transportation and is a cooperative effort among the nation's transportation information services and libraries. TRIS consists of an array of independent information services and libraries linked by a common on-line data base. This permits the search of data base records by keywords in titles and abstracts. The records searched consisted of resumes of on-going work and abstracts of the technical literature. Keywords used were as general as possible in an effort to identify as many references as possible. The search was conducted for the period from 1970 to the present.

The keywords "fire" and "flammability" were used in conjunction with "passenger vehicle" or "mass transit." Resulting from this search were 240 items, ten of which pertained to transportation research projects; the remaining 230 were published reports on related areas.

2.2 NATIONAL TECHNICAL INFORMATION SERVICE (NTIS)

The National Technical Information Service of the U.S. Department of Commerce is the central source for the public sale of reports on Government-sponsored research and development. Included in NTIS are analyses prepared by Federal agencies, their contractors or grantees, and by special technology groups. NTIS was searched both manually and with an automated information retrieval system. The manual NTIS search was conducted at TSC and covered the time from 1970 through 1977. Keywords used were "fire," "flammability," "mass transit," "combustion," "vehicles," "accidents" and "transportation." Approximately 100 items were identified in this search.

The automated search of NTIS was conducted at the Northeast Academic Science Information Center (NASIC) and covered the time from 1965 to the present. This search employed broader keywords than used in the manual search and resulted in the identification of 529 published reports. The keywords used included "fire," "fuel," "ignition," "hazard," "flashover," "flammability," etc. This search provided an overview of the areas covered by the major research programs. Aviation fire safety is the most extensive area of fire research. All of the reports identified in the manual search were also in the automated search. Many of the 529 reports identified were not pertinent to this project and have not been included in the bibliography of Appendix A.

2.3 ENGINEERING MONTHLY INDEX (COMPENDEX)

COMPENDEX is the engineering data base corresponding to the publication "The Engineering Monthly" produced by Engineering Index, Inc. This data base covers approximately 3500 sources of

world wide literature and conference proceedings in all engineering disciplines. The major content of this data base consists of published journal articles, whereas NTIS contains published reports on work sponsored by the Government. The COMPENDEX search was conducted at the Northeast Academic Science Information Center (NASIC) and covered the years 1970 through 1977. This search was restricted to reports written in English and utilized the keywords "fire," "flammability," "rapid transit," "inflammability," "railroads," and a combination of "fire" with "hazards," "protection," "prevention," "proofing," "resistance," and "detectors."

This computer automated search produced 150 items. Any duplication with the NTIS search was eliminated and the identified items were added to the bibliography of Appendix A.

2.4 MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT) LIBRARY

This search was conducted manually in the MIT library and consisted of bibliographies, monographs, journal articles and technical reports. Sources utilized for the search and keywords used were as follows:

SOURCES SEARCHED	KEYWORDS
Engineering Index, 1970-77	Aircraft Materials - Fire Resistance Flammable Materials Flame Research Materials - Fire Resistance
Applied Science and Technology Index 1970-77	Fire - Resisting Materials Flammable Materials Flammability Fumes Smoke Toxicology
Fire Technology Abstracts, 1976	Fire Safety, Transportation
Fire Research Abstracts and Reviews, 1970-74	Transportation (Air, Rail, Road, Water)
NASA, STAR, 1972-78	Flame Propagation Flammability

SOURCES SEARCHED	KEYWORDS
SAE, Cumulative Index, 4th ed 1966-75	Fires Flammability
Institute Library Catalog	Fire Flammability

This search produced 144 items many of which had been identified in the NTIS, TRIS and COMPENDEX. Duplication was found mainly in the technical reports.

2.5 SMITHSONIAN SCIENCE INFORMATION EXCHANGE (SSIE)

The Smithsonian Science Information Exchange (SSIE) contains information on current and recently completed research projects. This data base may be used to bridge the pre-publication gap. Input to the data base is provided by 1300 Government funding organizations. The SSIE was used to complement the information obtained from the modal agencies in section 3 below. Approximately 40 research projects were identified, many of which were not pertinent to this report. Furthermore, several of the presently active DOT research projects were not found in the SSIE data base, hence SSIE may be used only to complement the modal inputs.

2.6 TRANSPORTATION SYSTEMS CENTER (TSC) LIBRARY

All documents available in the TSC library and personal files pertaining to fire safety have been added to the bibliography.

3. GOVERNMENT AND INDUSTRY EFFORTS

An assessment of current fire safety efforts in both government and industry has been performed. Visits were made to a number of DOT and other government agencies. Still other agencies were contacted by telephone, as were several non-government sources. In each case, the information sought consisted of details of past and current research projects, either conducted in-house or contracted out, lists of published reports, rules and regulations promulgated, the establishment of data banks, and an indication of future work contemplated.

The results of this survey are presented below and show there is a great variance in consideration of fire safety. This is due to the agency experience, to risks perceived by the agency, and to the response to the degree of outside pressure applied.

One rather interesting observation was the lack of detailed data on transportation fire accidents. At present UMTA, CG, FAA, FHWA, NHTSA and FRA each have established or are in the process of establishing statistical data banks which include information from transportation fire accidents and are described in Section 4.2 of this report.

3.1 DOT EFFORTS

This section is intended to provide an overview of the fire safety programs of the DOT modal administrations and TSC. A more detailed explanation of the fire safety projects within the administration is contained in the technical resumes of Appendix B.

3.1.1 Urban Mass Transportation Administration (UMTA)

UMTA has been directly involved with the fire safety of rail rapid transit and bus systems since 1973, when it initially funded the Transportation Systems Center (TSC) to investigate various aspects of the fire hazard situations in vehicles funded under UMTA capital assistance grants. (See under TSC heading.)

Other programs supported by UMTA in the area of fire research:

- o Fire Detection, Extinguishment, and Materials Tests for an Automated Guideway Transit Vehicle, Nov. 1977. This work was performed at FAA/NAFEC. Report No. FAA-NA-76-52.
- o Study of Electrical Insulation, Contract No. DOT-TSC-1221. This study is being carried out by the Boeing Co. and is still in progress.
- o Fire Safety Evaluation of Automated Guideway Transit Vehicles. Interagency Agreement with National Bureau of Standards, Contract No. DOT-AT-70025. This work was recently completed.
- o Updating and Maintenance of Materials Data Bank. A contract (DOT-TSC-1534) for this work was awarded in March, 1978.

3.1.2 Federal Railroad Administration (FRA)

FRA fire safety efforts, in freight and passenger equipment, have been directed at tank cars for hazardous materials and the planning for a large scale fire test of a railroad passenger car. The passenger car fire test is designed to support AMTRAK in testing and evaluating selected railcar materials in the large scale fire environment. Aside from the two concerns above, FRA has generally addressed any fire considerations on a case basis.

3.1.3 Federal Aviation Administration (FAA)

The FAA has been investigating methods of reducing flammability of aircraft for the past 30 years. In general, these investigations have been quite extensive and involved two areas: fuel fires that occur during landing and take-off procedures, and flammability, smoke and toxic gas emissions of combustible materials used in aircraft interiors. Several programs underway at National Aviation Facilities Experimental Center (NAFEC) involve investigation of the effect of pool fires in terms of penetration into the interior of aircraft. A surplus C-133 for use in tests has been outfitted to simulate a wide-body airplane.

Current FAA regulations concerning flammability of combustible aircraft materials are contained in F.A.R. 25 and are discussed in Section A. A recent Notice of Proposal Rulemaking (N.P.R.) on smoke and toxicity specifications has been rescinded because of a desire to investigate the feasibility of a "Combined Hazard Index" (C.H.I.). The C.H.I. would be a means for combining the flammability, smoke and toxic gas emission into one figure of merit that would describe the hazard potential of individual materials.

The following are current activities in fire research being conducted by FAA, either internally at NAFEC or under contract:

- o Study of Combined Hazard Index - Contractor: McDonnell-Douglas 9/77 - 1/78, $75K. This is a feasibility study to be followed by a 20-month validation investigation.
- o Mathematical Model of Aircraft Fires - Contractor: U. of Dayton. This program has been in force for some time. It is expected that NASA/JSC will attempt validation of the model using a Boeing 737 test bed.

The following work is being conducted at NAFEC:

- o Pool fire effect on wide-body aircraft, using C-133 test bed.
- o FRUG modeling, a small scale simulation of the C-133 pool fire tests.

- o Study of pressure modeling simulation of large scale test.
- o Study of emergency lighting. Feasibility of placing emergency lights at arm-rest height rather than in ceiling.
- o Study to vent smoke into ceiling plenum in event of fire.
- o Testing service. Use of laboratory facilities to run small scale tests for material flammability, smoke and toxic gas characteristics.

NAFEC is operated by the FAA and its primary mission is responding and contributing to FAA research and development programs; testing and evaluating aviation concepts, procedures and equipment and assisting other organizations of the agency with research, development and implementation. With its extensive testing facilities NAFEC has conducted laboratory and full scale fire tests for both DOT and other government organizations.

The following is a list of recent reports issued by NAFEC that are of interest to ground transportation:

1. Fire Detection, Extinguishment and Materials Tests for an Automated Guideway Transit Vehicle. FAA-NA-76-52, Nov. 1977 (Sponsored under PPA UM-704, through TSC).
2. Evaluation of a Halon 1301 System for Postcrash Aircraft Internal Cabin Fire Protection. FAA-RD-76-132, Oct. 1976.
3. Measurement of Toxic Gases and Smoke from Aircraft Cabin Interior Materials Using the NBS Smoke Chamber and Colormetric tubes. FAA-RD-76-7.
4. Thermal Decomposition Products of Aircraft Interior Materials. FAA-RD-77-20. April, 1977. A companion report on the same materials tested for animal toxicity was issued by FAA/Civil Aeromedical Institute (CAMI): "Inhalation Toxicology" - FAA-AM-77-9, March. 1977.
5. Full-Scale Fire Modeling Tests of a Compact Rapid Response Foam and Dry Chemical Powder Dispensing System.

6. Evaluation of Firefighting Agents, Equipment, Systems and Techniques.

7. Evaluation of Aircraft Skin Penetrator Nozzle for Cabin Fire Protection.

8. Habitable Inert Atmosphere Using Carbon Tetrafluoride (Halon 1400).

9. USAF Fire Protection Program.

The Civil Aeromedical Institute (CAMI), an organization within FAA, also conducts fire safety research. The Toxicology Laboratory at CAMI has developed a methodology for the evaluation of the toxicity of combustion gases. This so-called toxicity protocol introduces gaseous products of combustion into a 12.5 liter chamber containing live rats as the test animals. Times to incapacitation and times to death are recorded. The method was recently used to evaluate the combustion toxicity of 75 aircraft materials. It was also used to evaluate the toxicity of a number of electrical insulations on the UMTA-funded program, "Study of Electrical Insulation."

Another group at CAMI investigates aircraft accidents to identify causative factors for injury or death, including those that occur in fires.

3.1.4 National Highway Traffic Safety Administration (NHTSA)

NHTSA is not currently funding any projects directed specifically at the fire safety of vehicles under its jurisdiction. There is, however, a NHTSA project directed at developing standard specifications for school buses. Included in this project, being carried out by A.F.L. Engineering Inc., is a requirement that the flammability and smoke emission of combustible materials be specified using the existing proposed UMTA materials guidelines.

The remaining NHTSA involvement in fire safety is through Federal Motor Vehicle Safety Standards (FMVSS) 301 and 302. FMVSS 301 requires a degree of integrity of automobile fuel tanks upon

impact of the vehicle at 30 mph. FMVSS 302 regulates the flammability of the combustible materials of construction of automobiles, buses, trucks and recreational vehicles. Discussions have been held between the UMTA Safety Office and NHTSA concerning the possibility of adopting future UMTA materials flammability specifications into FMVSS 302.

3.1.5 United States Coast Guard (USCG)

The Coast Guard is extremely conscious of fire safety and has the responsibility of developing and enforcing regulations concerning specifications of flammability and smoke emission of combustible materials under the Code of Federal Regulations Title 46. Under this Code, a number of different test procedures are used, depending on the material application.

Recently, the National Bureau of Standards was asked by the Coast Guard to review an Internal Organization for Standardization (ISO) Radiant Panel Test with the objective of substituting this test procedure for some current tests that are considered to be outmoded. The Coast Guard is also currently participating in a study of electrical insulation with the I.E.E.E.

The Coast Guard has specified the use of the proposed UMTA guideline specifications for materials used in the construction of jet hydrofoils by Boeing. The Coast Guard maintains a Fire and Safety Test Facility at Mobile, Alabama. This facility comes under the technical direction of the Coast Guard's Research and Development Center in Groton, Connecticut. A full-scale test site is located on Little Sand Island where two test vessels, a TI tanker and Victory ship, are moored. A recent series of fire tests was conducted on the containers employed on container cargo vessels (CCVs). Other fire tests conducted at this facility include: evaluation of new firefighting systems, evaluation of structural materials, evaluation of new materials for critical systems. The Coast Guard is unique in that many of the fire safety projects are conducted by in-house Coast Guard Fire Protection Engineers.

3.1.6 Office of the Secretary of Transportation (OST)

OST, through the Office of Environment and Safety, maintains an overview of the safety concerns of the various modal administrations within DOT. It has established a DOT Coordinating Committee on Fire Safety to encourage communication among the modes and foster the exchange of ideas and programs in areas of common modal interest. Resulting from the efforts of the DOT Coordinating Committee on Fire Safety and University Grants from OST have been the following efforts:

- Two small studies on passenger fire safety in all transportation vehicles. Completed in 1976. (Unpublished)
- A project to develop a fire safety technology assessment methodology for R&D funding. Partially completed, the project ended June 1977.
- A University Research Program to develop a protocol and combustion/exposure chamber for evaluating combustion product toxicity and smoke resulting from burning transportation materials. University of Utah, presently underway.
- A University Research Program project to develop an acceptability criteria for selection of safe materials for the interior of transportation vehicles. Center for Community Design and Research RICE Contract near completion.
- Simplified fault tree analysis of fire hazards in transportation vehicles.
- Review of standards and tests for material fire safety.
- Summary of statutory authority and federal regulations on passenger vehicle fire worthiness.
- Review of current DOT programs in fire safety.

At present, OST, in conjunction with the DOT Coordinating Committee on Fire Safety and supported by TSC, is developing an integrated program plan for the improvement of fire safety in transportation. Included in this project are the following:

- o A survey of the commonalities of current modal fire safety research, data bases, regulations and an analysis of the potential of cross application.
- o A review of the available fire safety data bases and a plan for improving fire safety data where necessary.
- o A review of modal fire safety regulations.

3.1.7 Research and Special Programs Administration (RSPA)

RSPA is comprised of the Materials Transportation Bureau (MTB), Transportation Systems Center (TSC) and Transportation Programs Bureau (TPB). Within this organization, fire safety efforts are presently underway in MTB and TSC.

MTB is involved in hazardous materials and pipeline safety operations and has performed fire safety research associated with the clarification of hazardous materials and hazardous material packaging in the fire environment. Recent MTB projects have been directed at the classification of oxiders, flammable solids, and spontaneously combustible materials and a study of the comparative behavior of plastic and metallic drums in a fire environment.

TSC involvement in fire safety is a result of its mission to provide support to the DOT modal administrations. The TSC effort in fire safety began in 1973 when TSC was asked by UMTA to perform the following:

- o Acquire information on combustible materials used in transit systems.
- o Evaluate these materials according to their flammability, smoke and toxic gas emissions.

- o Develop a materials data bank for storage and rapid retrieval of this information.
- o Develop proposed guideline specifications for materials selection.
- o Provide consultation to UMTA on non-metallic materials.

In FY 78, the TSC projects tasks were broadened as follows:

- o Assess current fire safety efforts.
- o Define the fire safety problem.
- o Identify methods for eliminating/minimizing the fire threat in vehicles.
- o Develop proposed transit system fire safety standards.
- o Assess the impact of proposed fire safety standards.
- o Evaluate the existing materials information bank.
- o Provide technical support.

The computerized materials information data bank established at TSC is unique in that it stores data on materials used or considered for use in transit vehicles. These data can be retrieved rapidly by manufacturer, trade name, area of application, composition or test procedure. Moreover, any of the materials in any category may be retrieved in ranking order in accordance with one of the many test procedures employed.

During the past three years, TSC's involvement in fire safety has broadened as support has been provided to OST and FRA. This support is described in Section 3.1.6 and has resulted in a display on fire safety not only with the DOT modal administration but also with other government and industry organizations.

3.1.8 Federal Highway Administration (FHWA)

The prime purview of this Administration is in roadways, tunnels and bridges. It leaves to the National Highway Traffic Safety Administration the general safety considerations involving

vehicles that use its highways. However, FHWA does have jurisdiction over the safe movement of dangerous cargoes such as explosives, flammables and other hazardous materials over the Nation's highways. They also regulate the fire extinguishers that must be carried by trucks.

3.2 OTHER GOVERNMENT AND QUASI-GOVERNMENTAL AGENCIES

3.2.1 National Railroad Passenger Corporation (AMTRAK)

AMTRAK is the quasi-governmental organization which operates passenger service over much of the country's rail system. Until 1976, specifications for flammability of combustible materials in its passenger cars was governed by the adopted specifications of the Port Authority of New York and New Jersey. In 1976, AMTRAK adopted the proposed UMTA guideline specifications under their specification GEN-S014-001.

The FRA continues to support AMTRAK's endeavor to up-grade the fire safety of their car interior components.

3.2.2 National Bureau of Standards (NBS)

NBS originated many of the standard flammability test methods that are in current use. They have no coordinated programs in transportation but, over the past years, have undertaken individual tasks in this area for FAA, UMTA, and the Coast Guard.

The following are some of the tasks performed that are directly related to transportation:

- Investigation of flammability of interior materials on the Washington Metro rail rapid transit and bus vehicles.
- Decision analysis on mobile homes for HUD.
- Investigation of flammability of BART vehicles.
- Study of flash fire potential of aircraft cabin interior materials for FAA.

- o Fire safety evaluation of automated guideway transit vehicles for UMTA. This program is expected to produce a rationale for establishing flammability guidelines, and will be presented to manufacturers and operators in a workshop environment.

3.2.3 National Aeronautics and Space Administration (NASA)

NASA's activities in flammability of materials of construction are conducted at NASA/Ames, NASA/Johnson, NASA/Lewis, and at the Jet Propulsion Lab. In addition, the FIREMEN Program has been contracted out to the three major airframe manufacturers (Boeing, McDonnell-Douglas and Lockheed).

NASA has developed its own testing methods which are necessarily conducted in atmospheres containing higher oxygen concentrations and at pressures other than atmospheric. Thus, much of the space data that has been obtained by small scale testing cannot be applied to ground transportation.

The FIREMEN Program was developed to explore some of the fire hazards associated with commercial aircraft and to develop new, more fire-safe materials for use in aircraft. NASA/Ames and NASA/Johnson lead in this Program. Among the three manufacturers, the following projects are underway in this five-year program which began in 1975:

- o Fire/toxicity testing of new materials to be used in cabin interiors (paints, films, molded parts, foams, fabrics).
- o Fire-hardened interior sandwich panels
- o Fire-hardened lavatory designs
- o Fire-hardened cargo compartments
- o Large-scale tests of components.

3.2.3.1 NASA/Ames Research Center

The Ames Research Center is one of the principal NASA centers for the development of advanced materials concepts for aerospace

and commercial aircraft applications. The fire safety of these materials is a prime objective.

There are four basic programs:

1. New polymers for structural and nonstructural applications.

   Screening and fabrication of prototypes.

2. Test methods.

   Fire characterization.
   Toxicity testing.
   Simulation techniques.

3. Toxic threat assessment of fighter aircraft.

4. FIREMEN program (Fire resistant materials).

The goals of this program are to:

- o Provide materials technology for reducing flame propagation, smoke and toxicity in cabins.
- o Increase fire containment capability in selected areas of the cabin and the cargo hold.
- o Evaluate fire resistant transparencies.
- o Develop advanced seat cushion systems.
- o Provide materials technology for fire-resistant films, adhesives and inks.

3.2.3.2 NASA/Johnson Space Center

NASA/JSC materials laboratories conduct extensive testing of materials, primarily for spacecraft. NASA/JSC is the center for large-scale testing of aircraft interior fires, conducted at atmospheric conditions. This work has resulted in the issuance of the Non-metallic Materials Design Guidelines Test Data Handbook. The handbook is a compendium of data resulting from the testing of thousands of materials by NASA-developed testing methods. The data are of little value to the non-aerospace community because the data are obtained at other-than-atmospheric conditions.

3.2.3.3 NASA/Lewis Research Center

NASA/Lewis was at one time deeply involved in aircraft safety, including fire safety. The Aerospace Safety Research and Data Institute (ASRDI) Data Bank was established at Lewis in 1968 but in the past few years has not been funded for updating and maintenance. Responsibility for this work has been transferred elsewhere in NASA. Lewis retains a major role in propulsion system fire safety.

3.2.3.4 Jet Propulsion Laboratory (JPL)

The Jet Propulsion Laboratory is operated, under a NASA contract, by the California Institute of Technology. JPL has several projects concerned with the fire characteristics of materials. Among these projects are the development of fire models for materials, smoke properties of electrical insulation material and development of flame retardant panels.

3.2.4 National Fire Prevention and Control Administration (NFPCA)

The National Fire Prevention and Control Administration was established by Congress in 1974 in response to criticism that the federal government was not paying sufficient attention to the severe problem of fires in this country. Under the Department of Commerce, they are working to establish a national policy on fire prevention and control. Their four functions are:

1. Establishment of a Fire Academy
2. Establishment of a National Fire Data Center
3. Office of Public Education
4. National Fire Safety and Research Office.

The goal of the National Fire Safety and Research Office (NFSRO) is to provide the planning, research and technology to decrease significantly fire-caused deaths, injuries and economic losses, and to improve the cost effectiveness of fire protection. This is accomplished through: 1) Operation, Planning and Evaluation, 2) Technology Development, 3) Regulatory Impact, 4) Planning and Management Research, and 5) Fire Safety Research. Grants and

contracts are the primary vehicles by which NFSRO accomplishes its objectives.

Although several of the NFSRO functions in fire research have been transferred tc the NBS, it will continue to be among the most important contributors to basic understanding of the nature of fires and the practical side of fire ignition and propagation in building structures. As a central government collector of fire data from state and local fire departments, its data bank could be of use to UMTA.

At the present time, DOT assistance to the NEPCA will be most beneficial to NFPCA. This small agency has not yet had time to enter the area of transportation but it recognizes the necessity to do this eventually as part of its overall review of fires and fire hazards in this country.

A list of its past and current programs will be found in the document, "Catalog of Grants, Contracts, & Interagency Transfers" published by NFPCA.

3.2.5 National Transportation Safety Board (NTSB)

The NTSB investigates transportation accidents of all types which involve loss of life or a large property loss. It does not cover automobile accidents in which only property loss is involved. Reports are written and recommendations are made directly to Congress.

Generally, the NTSB does not investigate the role of materials in fire accidents; however, it does sometimes criticize current regulations or lack of regulations. One example of this occurred after a series of bus fires in Washington, D.C. in 1975, which culminated in the death by smoke inhalation of one passenger. The NTSB recommended that NHTSA's FMVSS 302 be expanded to include a vertical burn test of all vehicle interior materials and to establish an acceptable vertical flame spread index similar to that prescribed by the FAA in 14 CFR 25.853, as appropriate. They also recommended a provision for a sufficiently long period

of time for occupant evacuation before the creation of a lethal environment resulting from fire. (NTSB Safety Recommendation H-75-12 and 13.)

An NTSB spokesman expressed a strong preference for the reporting of fire accidents by means of scenarios as a means of providing the maximum amount of information that would be useful in understanding ignition and fire spread. Scenarios are also useful in the preparation of specifications and regulations.

3.3 INDUSTRY ASSOCIATIONS

3.3.1 American Public Transit Association (APTA)

APTA is the national organization representing the urban transit community. The objectives of APTA include: to represent the interests, common policies, requirements and purpose of the operators of public transit; to provide a medium for exchange of ideas and experiences; to promote research and investigation; to encourage cooperation among its members, their employees and the general public; to collect, compile and make data available to members.

A recent consolidation brought the Transit Development Corp. (TDC) into APTA. TDC was initially formed by APTA as a research and engineering organization to support technical work and provide advisory services to ongoing research. TDC supported work at Ohio State University on a calorimeter designed to provide flammability and smoke data on individual materials used in transit systems. Some work on modeling of vehicle fires was also done on this program.

A report entitled, "Monograph Series 500," was issued containing information on committee conclusions as well as the university-supported work. APTA has also provided an Advisory Board to assist the UMTA-sponsored program, "Study of Electrical Insulation."

3.3.2 Union Internationale des Transports Publics (UITP)

UITR is an international organization of transit authorities, one of whose prinicpal safety concerns is fire. The various members have conducted test programs on problem materials such as foam seat cushions, polystyrene lighting fixtures, vinyl fabrics, polyester reinforced plastics and electrical insulation.

The subcommittee on electrical insulation, consisting of the U.S., Great Britain, France and Sweden, meets annually and compares research programs. At present, a program involves work being done at the N.Y.C.T.A., which acts as the U.S. representative. Wire and cable from several manufacturers are being tested for flammability, smoke and toxicity (live animal tests).

Reports of the main committee are issued after each bi-annual meeting, and of the sub-committee, annually.

3.4 INDUSTRY

3.4.1 Materials Manufacturers

The current material concern for fire safety that has resulted in the establishment of such government watchdog agencies as the Consumer Products Safety Commission and the National Fire Prevention and Control Administration has had a considerable effect on manufacturers of materials. Realizing that many of the users, such as transit systems, are now requiring fire safety specifications to be met, manufacturers are increasingly testing their materials to flammability, smoke, and, in some cases, to proposed toxicity standards.

Some of the larger manufacturers, such as DuPont, Monsanto and General Electric, have constructed fire test areas, where large scale as well as laboratory tests on components can be conducted. This activity has led to the development of new materials and the improvement of the fire safety of some of the older materials.

3.4.2 Materials Users

For reasons similar to those in 3.4.1 above manufacturers of transit vehicles and transit authorities have been tightening their specifications regarding flammability and smoke. Some transit authorities have conducted flammability tests on components, such as groups of seats. Others have plans to conduct full-scale tests on old vehicles fitted with a variety of new materials. As a rule, however, they rely on certificates of compliance, with their specifications, from the materials' manufacturers.

4. MATERIALS AND STATISTICAL DATA BASES

This section describes the existing Materials and Statistical Data Bases pertaining to transportation. A materials data bank is defined as one which contains data on the results of tests on materials related to their mechanical, physical and chemical properties; and for the purposes of this report, flammability, smoke and toxicity data as well.

A statistical data bank stores information relative to the accidents/incidents involving the safety of transportation systems; the numbers of such accidents/incidents that occur in different types of vehicles, the source of the events and the extent of injury or damage.

4.1 MATERIALS DATA BANKS

A materials data bank is a repository of collected information on properties of materials. Considering the vast number of different types of materials that can be used in transportation systems and the large number of different properties exhibited by each, a comprehensive data bank must necessarily contain a large number of records.

To be really functional and useful, the data bank must embody a rapid retrieval system such as a computer-based software program. The computerized system has many advantages, in that it permits grouping of retrieved data in whatever manner the search requires. Rapidity of retrieval is also a vital attribute of such a system.

4.1.1 Types of Materials Data Banks

There are two general types of materials data banks: (1) those that contain references to journal articles, reports and other sources which contain only the properties data in some organized manner.

Data banks of the first type generally provide lists of document sources which contain information on a particular type of material. One then has to obtain the documents (a very tedious task), and then contact these sources for the particular pertinent data. This might then be followed by a process of assembling the data into some meaningful arrangement.

The second type of data bank stores materials data in terms of categories that include the following: manufacturer, trade name, application, type of material, composition, source of data, and the results of a wide variety of test procedures. The data can be retrieved in any manner permitted by the software program. For example, any of the above categories can be retrieved separately. If information is desired as to behavior under a particular test condition, the data may be obtained in an ascending or descending order of merit. The behavior of individual materials can also be obtained.

The advantages of the second type of data bank are obvious; the required data are rapidly retrievable, and comparison among the various materials in any of the test categories can be readily made. Transmission of the data can then be made to the interested parties in a form that can be readily interpreted. A further advantage lies in the ability to upgrade existing data, add new data, and delete obsolete data as necessary .

One of the tasks of this project was to search, identify and evaluate existing materials data banks. This search was conducted among various government agencies, private organizations and industry. The result of this search is described below.

4.1.2 NASA Search and Retrieval Division, Scientific and Technical Office (KSB), Washington DC

This NASA source will conduct a literature search if provided with key words. The search will obtain the titles of documents, names of authors, dates of documents and abstracts. Copies of original documents are not provided.

4.1.3 NASA/Johnson Space Center, Houston TX

The Johnson Space Center has had a Materials Development Group for many years. This group developed specifications for the materials for various manned and unmanned space flights and have issued a compendium entitled, "Nonmetallic Material Design Guidelines and Test Data Handbook." This handbook contains flammability data on thousands of different materials tested at the Center. This data is not useful for our purposes for two reasons: (1) the test methods were developed by NASA and are used only by NASA. They differ from other standard tests, and it is not possible to use a correlation factor. (2) The tests are made under other than normal atmospheric pressure and oxygen concentration.

4.1.4 Air Force/Wright-Patterson Air Force Base, Dayton OH

This Air Force materials center maintains a computerized data bank that can be addressed for a literature survey, by contacting the Defense Documentation Center.

In October, 1976, the first section (AFSC DH 1-7) of a handbook on aerospace materials was issued. This section is devoted to test procedures and flammability test results on a number of fabrics used in aircraft. Data collection has been discontinued for lack of funds.

4.1.5 Plastics Technical Evaluation Center (PLASTEC), Picatinny Arsenal, Dover NJ

The PLASTEC group is supported by DOD for the purpose of storing, cataloging and disseminating information on all types of plastics, plastics processing and their uses that could be of interest to DOD. The output is in terms of a literature search. Journal articles and conference pages are cited with short abstracts. Occasionally, a report is issued which contains all collected information on one type of material, for example, polyurethane.

A computerized data bank which will specialize in mechanical data of plastics and plastic composites is being developed but is still some time away from completion.

4.1.6 National Bureau of Standards (NBS)

The National Bureau of Standards has carried out fire research primarily in the areas of building technology and fire testing of materials since the early 1900's. Under the Federal Fire Prevention and Control Act of 1974 the NBS Fire Research Center was established and this activity at NBS received further emphasis.

NBS has no automated data base; however, it has a fire research library consisting of 20,000 documents and reports published within the past eight years. It also has an older collection dating from 1967-1970 which may be accessed by title and keyword, using a manual system.

Its interest in transportation fires is fairly recent so that material on transportation fires is not extensive.

4.1.7 General Electric Company Materials Information Service, Schenectady NY

The General Electric Company has a materials data bank covering about 12,000 materials of all types used within the company. This data bank is available for G.E. use only.

A recent effort by General Electric has involved compiling data on health and safety aspects of materials by class, e.g., solvents and "hot" metals. This involves using an Occupational Safety and Health Administration (OSHA) format on hazards, disposal, etc. They now list 300 substances. No attempt has been made to market this bank.

The service is allowed to do outside consulting work such as literature searches. They recently completed a search for the National Bureau of Standards to evaluate data sources on mechanical properties of metals.

4.1.8 DOT/Transportation Systems Center

The computerized materials data bank located at TSC was designed to meet all the requirements of the second type of data bank. Furthermore, it is dedicated to materials used in transit systems.

A separate report which describes in detail the contents and functions of this data bank is being prepared. Briefly however the information stored in the bank includes data for seat cushions, frames and upholstery, carpeting, wall and ceiling panels, flooring, acoustical, thermal and electrical insulation, plastic glazing and lighting diffusers, and other combustible components.

The following categories of data on the combustible materials are stored:

a. Flame spread (by given test method)
b. Smoke evolution (by NBS smoke chamber)
c. Toxic gas evolution
d. Durability and maintainability
e. Mechanical and chemical properties
f. Cost,

There is also a category on fire extinguishers, chemicals and extinguishing methods, including hazards inherent in their use.

The data bank is designed to be updated on a continuing basis, which will include the addition of new categories when this is deemed necessary. Retrieval of information is obtained in terms of individual items, categories and orders of merit by any of the data categories.

A one-year contract was recently awarded to the Boeing Commercial Airplane Co. to update and maintain the data bank. Data obtained by TSC, the Boeing Materials Section and other reliable sources will be added.

Since there is a commonality of materials usage among the various Modal Administrations of DOT, it is likely that the information stored here will be of considerable value to the FAA, FRA, Coast Guard and others.

4.2 STATISTICAL DATA BANKS

A basic difference in statistical data banks is between those which function primarily as (1) a set of cases and an index and (2) analytical bases which function as tools of statistical analysis. The characteristics of each of these basic classifications are as follows:

1) Cases and Index Type: In this type, there is generally no statistical design involved in the data collection, although in some cases the records may represent an entire population with certain specified attributes. There are no statistical samples. The file refers back to an accident report, an investigation report, or some other record.

2) Analytical Type: In this type the data base is specifically designed so that it may be manipulated statistically; i.e., statistical tests may legitimately be applied. The data base is complete in itself; it does not refer back to other documents.

Statistical data banks also differ as to their inclusiveness with respect to geographic coverage, transportation modes, classes or types of fire accidents/incidents, damage and casualties, origin of fires, causes or probable causes, and the general level of detail of the data.

Some data bases simply indicate whether or not a fire occurred. Others provide additional material such as the identification of the vehicle or equipment involved, including the year, make, model, and serial number; the origin of the fire, the cause or probable cause, operation of fire detection and fire protection systems, fire fighting actions, emergency medical service activities, estimates of property damage, the number of persons injured - including burns, and the classification of the burns that were suffered.

The source of data varies from data base to data base. In some instances data are supplied by the carriers. In other instances the data are supplied by local police and fire departments or by federal investigators or analysts.

In the compilation of statistical data bases which follows, all summary descriptions refer to systems that are maintained by the federal government, with the single exception of the system that was developed by the National Fire Protection Association, (NFPA), a private non-profit organization. This compilation represents those data bases which have been surveyed thus far. Additional information will be provided at a later date on data bases maintained at other levels or government, at university research centers, and in industry.

4.2.1 The National Fire Protection Association (NFPA) Fire Incident Data Organization (FIDO)

In 1971 the NFPA started the data base referred to as Fire Incident Data Organization (FIDO). There are two types of entries contained in the data base: (1) case histories, and (2) statistics of fire losses and casualties. The data base is intended to provide

informational support for NFPA committees and publications. Each year NFPA published a report on large losses as a result of fire; i.e., concerning fires in which there are multiple deaths or property losses exceeding $250,000. Data for this report are drawn primarily from FIDO. In addition, FIDO is used by people outside NFPA, including government agencies and legislatures, research contractors, manufacturers, law firms, and news media.

Criteria for the inclusion of fire incidents in the data base are:

1. severity of the fire,
2. occurrence of a death or of property damage exceeding $100,000,
3. the involvement of hazardous materials,
4. exemplary fire prevention or fire fighting.

At present approximately 38,000 incidents are in the file; 5000 to 6000 incidents are added per year. FIDO can output abstracts of the fire reports, can search eight data elements simultaneously to narrow a search, and can output casualty and loss figures. It is primarily an index and a file of reports rather than a tool for statistical analysis.

NFPA also maintains an information exchange with insurance companies concerning so-called "highly protected risks" (HPR). When a fire incident is to be included in the data base NFPA requests the fire department to use an NFPA form that is composed of 150 items, most of which are form the NFPA 901 Code. Very few of the incidents in the file involve transportation facilities. There are no data identifying vehicle make, model, and year in transportation fires. NFPA does not track fire experience of proprietary products although they will compile information on generic characteristics.

4.2.2 National Transportation Safety Board (NTSB)

The National Transportation Safety Board maintains data bases on all NTSB investigations of aviation accidents/incidents and on certain rail, auto/track, bus marine, and pipeline accident investigations. Fire and explosions are included in the definition of accidents/incidents.

Aviation

The definition of "aviation accident" as given in Title 49, Part 830 of CFR is an occurrence in which death or personal injury is involved and/or in which there is "substantial damage" requiring major repairs to the aircraft. Information is obtained from notifications of accidents and from field investigations. The information given to NTSB in a notification of an accident includes information concerning the aircraft, the trip, and the operator of the aircraft. It also includes information concerning casualties, the nature of the accident, and the extent of the damage to the aircraft. The aviation accident report, resulting from a field investigation by NTSB, includes the facts, conditions, circumstances, and determination of the cause or probable cause of the accident, submitted approximately six months after each accident. Reports are provided by computer printout and are published periodically as "Briefs of Accidents." In addition, the members of the NTSB issue recommendations concerning transportation accidents and safety. These recommendations are included in each accident report.

NTSB classifies aviation fires as fires in flight or fires after impact. These data can be examined for commonalities. The significance of these data can be best interpreted in relation to other commonalities/differences such as crashworthiness of aircraft, design features, etc.

Data extracted from the notifications and the field investigations are maintained in a computer file. "Briefs of Accidents" are automated. Also, the recommendations made by the Board members are now automated and may be accessed on a keyword basis; e.g., by type of aircraft.

Surface Transportation

The Bureau for Surface Transportation is in the process of writing programs and developing computer data bases. Any surface transportation accident investigated by the NTSB and certain marine accidents investigated by USCG result in a formal Board report. The report provides information on the facts and circumstances of the accident and includes the NTSB's determination of the cause or probable cause of the accident. NTSB investigations of certain railroad accidents include the urban rail transit category and generally cover rail accidents resulting in a fatality or the emergency evacuation of persons. Information collected in the notification and investigation of surface transportation accidents includes a description of the accident, casualties, fatalities, injuries, estimated property damage, and the determination of cause or probable cause.

The Bureau of Surface Transportation issues "Briefs of Accidents" and issues full reports and recommendations of the Board. It is expected that when the computer data base becomes operational sometime in the future, records going back to March 1976 will be included. Information regarding reference to fires in the automated data base is not available at the present time.

Pipelines

The data base of pipeline accidents, including fires and explosions, consists of 36 reports from 1969 to the present. Pipeline data are not yet on an automated basis, but they may be accessed on a keyword basis. Accidents resulting in "substantial damage" ($100,000 or more) or fatalities are investigated. Fatalities may occur at the site or at any time later. The investigation reports and NTSB's recommendations include information on the operation of combustible-gas, leakage-indicators and fire-extinguishing.

4.2.3 The National Fire Incident Reporting System (NFIRS)

The National Fire Incident Reporting System (NFIRS) is being developed by the National Fire Protection and Control Administration (NFPCA) of the U.S. Department of Commerce in partial fulfillment of the mandate of the Federal Fire Prevention and Control Act of 1974. NFIRS is intended to serve as a collection of national fire loss statistics of fires that have required action by fire departments. Data are collected concerning the factors involved in fire ignition, spread, extinguishment, and fire loss and casualties.

NFIRS also includes procedures for achieving uniform fire data reporting at local, state, and federal levels. NFPCA is working with the NFPA and the NBS to develop the reporting procedures and the data base. The NFPA No. 901 Code has been used as the basis of the NFPCA fire reporting code.

Data collection for NFIRS began in 1976 in five states: Ohio, California, Oregon, Missouri, and Maryland. Recently, sixteen additional states have been added: Tennessee, North Carolina, New York, Delaware, Maine, West Virginia, Illinois, Wisconsin, Minnesota, Michigan, Montana, South Dakota, Utah, Alaska, Iowa, and Rhode Island. Data are collected on transportation fires as follows:

transportation mode
year, make, model, and serial number of vehicle
license number
origin of fire
fire fighting actions

fixed properties at site of fire; e.g., airport, RR yard
vehicle part involved in fire
ignition source
type of material; e.g., gasoline, rubber
category of material; e.g., fuel, tire
method of extinguishment

estimated total dollar loss
property damage classification
time from alarm to agent application
casualties - type, severity, location, cause of injury, nature of injury, part of body injured, condition preventing escape, activity at time of injury.

Each fire department is identified and each fire incident within a department for any given year is assigned a unique number. A supplemental number, the "exposure number," is assigned to other properties or vehicles involved in a fire. Through use of the incident and exposure numbers all property involved in a single fire incident may be related. A separate report is made out for each exposure. Every incident and exposure is dated and the time of the alarm is recorded. There are now approximately 648,000 incident reports in the file. It is difficult to estimate how many of these involve transportation properties. The combined number of equipment and mobile property incidents in the file is approximately 54,000, or approximately 8% of the incidents.

Transportation data may be extracted from the file and various cross-tabulations may be made by NFPCA either at no cost or at a fee commensurate with the difficulty of the request.

4.2.4 Federal Railroad Administration

The Federal Railroad Administration (FRA) maintains a computerized data base consisting of information on accidents/incidents that are filed monthly by the railroads. Train accidents are events, with or without casualties, arising in connection with the operation of railroad on-track equipment which results in more than $2300 damages to rail equipment. Train incidents are events in which damage to rail on-track equipment is less than $2300 but which result in reportable death, injury, or illness.

UMTA is presently developing a formal accident/incident reporting system for rail rapid transit. At present, UMTA is provided operational data by the FRA or the individual transit authorities.

There are three Primary Groups of accidents/incidents in the FRA data base, as follows:

Group I Rail-Highway Grade Crossing
Group II Rail Equipment
Group III Death, Injury, and Occupational Illness.

Forms, filled out by the railroads, correspond to each of these groups. Under Group II, Rail Equipment, there are 12 different categories of accidents/incidents. Many of these categories cover different types of collisions; however, one category is called "fire or violent rupture accident/incident."

The information on fires that is entered into the FRA file is very meager. It identifies the vehicle involved in the fire. If it is a locomotive, the code used on the form permits identifying the cause of the fire as "oil fire," "electrically caused fire," or "cause code not listed." In the last case the explanation is written on the form but probably is not entered into the computer file. If the fire occurs in a freight or passenger car (rather than in a locomotive) there is no cause code listing and an explanation must be written on the form. Given these constraints, this data base may be accessed to provide tabulations and statistics on railroad fires.

According to the Accident/Incident Bulletin No. 144, published by FRA in calendar year 1975, there were 8 incidents involving electrical flash, shock, or burn; 9 incidents involving fire or explosion of fuses or torpedoes; and 10 incidents involving other fires or explosions. It also reports 7 locomotive accidents with oil fires listed as a cause and 44 listed as electrically caused fires. In the Bulletin there is no other breakdown of fires.

4.2.5 National Highway Traffic Safety Administration

At present, the National Highway Traffic Safety Administration (NHTSA) maintains a Fatal Accident Reporting System which is a file of all traffic accidents occurring on highways that result in a fatality, within the fifty states and Puerto Rico. Data are compiled from police reports and from news clippings. The data

relating to fires are limited, indicating whether fire or explosion was involved in the accident, whether an emergency medical services unit was on the scene, and whether it was necessary to extricate the victim from the wreckage. From these records there is no way of assessing whether fire was a cause of death. The major value of this file for our purposes is that it provides data on how many fatal traffic accidents were associated with fire.

NHTSA started work on a new data system, on April 3, 1978, that will provide additional information on highway fires. This data base, the National Accident Sampling System, will be operational in 1981/1982. NHTSA will sample 20,000 accidents per year. Teams of investigators will interview police and will inspect vehicles and hospital records. Information relating to fires will include records of whether fire occurred, whether any fires were internal or external to the vehicles involved,the extent of the fire, its location, cause and other details. NHTSA can oversample certain types of accidents - such as fires - for a limited period of time, if such data are called for.

NHTSA has also entered into an interagency agreement with the U.S. Consumer Product Safety Commission. Under this agreement the CPSC will expand its National Electronic Injury Surveillance System (NEISS) sample of highway casualties, and will retrieve reports from additional hospitals, as well as data on severity of burns, and police accident reports on subsets of cases. Prior to the NHTSA agreement, NEISS concentrated on injury and hazard information associated with household products. This information was collected from hospital accident rooms.

4.2.6 Federal Highway Administration/Bureau of Motor Carrier Safety

The Bureau of Motor Carrier Safety maintains a large file of records on accidents, including fires, of carriers involved in interstate commerce. Approximately 30,000 records are added to the file each year. The file has been computerized since 1973. All accidents involving a fatality, serious injury, or property damage over $42,000 are entered into the file.

Approximately thirty questions are asked on the forms. Included are such entries as type of trip, and the accident classification. In accidents which were non-collision, an indication is requested as to whether fire was involved, and whether fire occurred in the cases involving collision. Other information indicates whether a mechanical failure occurred, whether hazardous cargo was being transported, and what type of fuel was used in the vehicle.

4.2.7 United States Coast Guard

The Coast Guard has three different data bases which include information on fires. The first is provided for USCG's own vessels and facilities; the second covers accidents involving merchant vessels; and the third covers boating accidents and fires. The characteristics of each of these data bases are as follows.

USCG Vessels and Facilities

The Coast Guard uses DOT Form Supplement F in reporting fire incidents. A computer file of the data is maintained. Information on the cause of the fire, personal injury or death, and the amount of damage in dollars is included. Data on the type of alarm system present, whether it was activated, the type of extinguishment, and whether fire-fighting was self-help or outside help is also maintained in the file. The narrative portion of the form includes information on the part of the vessel or facility involved but this information is not entered into the computer. The file was started in 1970. In 1977 there were 37 reported incidents.

Merchant Vessels

Since 1953 a computerized data base has been maintained on all casualties, including fires and explosions, that have occurred on merchant vessels. There are approximately 65,000 records in the data base, about 5,000 records being added each year. Included in the data base is information concerning death or injury, loss

of vessel, damage over $1500, the identification of the vessel, its location, the cost of damages to the vessel and to the cargo. General information is given as to the nature of the fire and where it started; e.g., engine room, cargo, liquid bulk. Probable cause is also listed, such as improper stowage, carelessness of personnel, or electrical fire. Records are available on microfilm going back to 1972. Yearly statistics are published, including those on fires and explosions.

Boating

The third data base maintained by the Coast Guard relates to fires (and other accidents) in recreational boats. There is a large body of data on fires which is not computerized but is published in research and development reports. Boating accident reports from 1969 to the present are stored on microfiche.

In addition, there is a computer file which serves both as an index to the microfiche reports and which also includes information extracted from each report. The descriptors entered into the computer include the following: case number, state, GSA county code, USCG District, age of operator, operator's experience, whether boat was owned or rented, the number of people aboard, the manufacturer's identification number or code, type of boat, hull material, engine type, horsepower, length, year built, data of accident, body of water, weather conditions, water conditions, water temperature, visibility, the type of operation at the time of accident or fire, type of accident, whether life jackets or lifesavers were used, the amount of property damage, the number of people drowned, other victims, other injuries, and number of vessels involved. Under causes of fires are included: equipment failure - fuel system, electrical failure, auxiliary equipment; miscellaneous, such as the emission of spilled fuel or vapors, misuse of source of heat, or other, or unknown, causes. Accident descriptors include: could not reach fire extinguisher, extinguisher capability, improper ventilation or failure to vent before starting, and operator's contribution to fault. Records are entered into the data base within three to four months following

an accident or fire. There are about 50,000 to 60,000 records in the file.

Statistics on boating fire can be produced for TSC upon request. Report No. 357 is published annually on boating accidents and fires.

4.2.8 Federal Aviation Administration

The FAA maintains three data bases which contain information concerning aviation fires. The Safety Analysis Staff of the Flight Standards Service has a file of 3500 general aviation accidents/incidents going back over a period of one and a half years and a file of 1450 records of air carrier accidents/incidents over the three year period, 1975-1977.

The FAA Aeronautical Center, Oklahoma City, maintains a Service Difficulty File which contains information of fires in flight, for both air carriers and general aviation. It does not include post-accident fires following impact. There are 100,000 "events" in this file, an event being an accident, incident, or difficulty in flight. Generally there are 20,000 events a year in this file, which has been in existence five years. The record for each event includes data on causes; e.g., fuel leak, failure or defect in cylinder, manifold, etc. Data are included on the severity of the damage; in most cases of fire in flight the aircraft is destroyed. In cases in which it is not destroyed, the extent or damage is indicated. Information is included as to whether the fire warning indicator operated. In 90 per cent of the cases, fire warning operation turns out to be a false alarm. There is little information on fire fighting. If the record is of an accident, there is cross referencing with the NTSB report of the accident, including the toxicology report.

4.2.9 Summary of Statistical Data Banks

Table I summarizes selected characteristics of the data bases discussed above.

TABLE 1 SUMMARY OF DATA BASES

DATA BASE	AUTOMATED	MANUAL	DETAIL* OF FIRE DATA
Case & Index Type			
NFPA-FIDO	X		moderate
NTSB-RAIL		X	high
NTSB-PIPELINE		X	high
NTSB-RECOMMENDATIONS	X		NA
Analytical Type			
NFPCA-NFIRS	X		high
FRA	X		low
NHTSA-FATALITIES	X		low
NHTSA-NATL. SAMPLE	X		high
FHWA/BMCS	X		low
NTSB-AVIATION	X		high
USCG	X		high
FAA	X		high

*DEFINITION

Level of Detail of Fire Data

Low: Indicates whether fire occurred. Limited or no information on origin of fire, causes damages, or casualties.

Moderate: Indicates origin of fire. General classification of causes but no disaggregation. Includes general information on damages and casualties.

High: Provided data on origin of fire and on cause. Provides additional information on causes, severity of casualties and damage, refers to operation of fire detection devices, extinguishment, emergency medical services unit, and other circumstances of the fire accident.

5. AVAILABLE STANDARDS, GUIDELINES, SPECIFICATIONS AND RECOMMENDATIONS

Standards, guidelines, specifications and recommendations for fire hazards differ considerably in their function and impact on the community. They are frequently misinterpreted and are sometimes erroneously used interchangeably.

5.1 DEFINITIONS

A standard is a rule, promulgated by an authority having jurisdiction, which establishes an appropriate level of performance for a material, component, subsystem or system, or for an integrated product composed of materials, components, subsystems or systems.

A standard test method is a promulgated test method which has been examined, approved and documented by an organization having recognized expertise in a given area.

A guideline is a rule or series of rules promulgated, by an authoritative source, to provide guidance in the establishment of a regulation.

Recommendations result from the study by authoritative individuals of a scenario or series of scenarios concerning common events, and proposes corrective measures.

A specification is a precise statement of a set of requirements to be satisfied by a material, product, system, or service, indicating, whenever appropriate, the procedure by means of which it may be determined whether the requirements given are satisfied. As far as practicable, it is desirable that the requirements be expressed numerically in appropriate units together with their limits.

5.2 STANDARDS

There are many so-called "Standards Organizations" which are recognized as authoritative in their fields. The manner in which they function differs quite widely, and they may be divided into

the following categories:

5.2.1 Consensus Standards Organizations

This type of organization is the broadest category and consists of members from industry, government and academia with a common interest in an orderly systemization of definitions and testing procedures. They develop standards on characteristics and performance of materials, products, systems and services; and the promotion of related knowledge.

Two organizations of this type which issue standards or interest in the field of flammability are: the American Society for Testing and Materials (ASTM) and the National Fire Protection Association (NFPA). Both organizations operate in similar fashion. Each is divided into many committees and subcommittees with particular, narrow interests in a sub-set of materials, applications or procedures.

When a new standard test procedure is proposed, a subcommittee is assigned to work out the details of definitions, scope, and technical procedures. Often, round robins of the proposed test method are conducted and the results correlated to provide verification of the procedures or to make changes. The proposed standard is then voted on by the full committee and finally sent to the main organization for approval.

The NFPA established a Committee on Rail Rapid Transit in 1974 which was asked to revise its standard on fire protection and prevention in Transit Operations, originally issued in June, 1959. The Committee has been deadlocked on several issues for some time. A new chairman was recently appointed, but the committee remains inactive with no present prospects for revival.

The ASTM has a subcommittee on transportation under the committee E-5 on Flammability Test Methods. This committee is relatively new and its impact remains to be determined.

5.2.2 Independent Laboratory Standards

The major promulgator of this type of standard is Underwriters Laboratory (U.L.). Over a period of many years, U.L. has issued many flammability standards as well as standards in other areas such as wire and cable construction and connectors. These standards are widely used.

5.2.3 Military Standards

The military services have issued many standards relating to materials and procedures for use by all of the services. The standards often include specific test methods to be used in evaluation of particular classes or materials. Some of these appear in the Coast Guard specifications for flammability.

5.2.4 Federal Test Method Standards (FTMS)

FTM standards are similar in scope to the Military Standards but encompass a brcader spectrum of materials of interest to all federal agencies. It is expected, however, that these standards will gradually be phased out in favor of ASTM standards. One of these standards, FTMS 372 on Flooring Radiant Panel Test, is employed by AMTRAK.

5.3 STANDARDS UTILIZATION

Flammability standards are used in the preparation of specifications which are made up for the construction of vehicles. Generally, known standards prepared by well-known standards organizations are employed. The reasons for this are obvious: The standards have been "accepted," and the equipment for the standard test methods are available in many laboratories. However, there are no current federal standards for use in specifications for rail-rapid transit vehicles and buses.

5.4 DEPARTMENT OF TRANSPORTATION STANDARDS

Until recently the only Federal Standard employed for ground transportation was Motor Vehicle Safety Standard No. 302 which was promulgated by the National Highway Safety Administration for

application to automobiles, trucks, buses, and recreational vehicles.

Specifications issued by UMTA for TRANSBUS and the Advanced Design Bus have employed flammability specifications other than MVSS 302.

The Federal Aviation Adminstration uses a flammability standard adapted from the Federal Test Method Standard CCC-T-191b, Method 5903 for testing of fabrics as well as plastic materials. FAA currently has a contract with McDonnell-Douglas to investigate the feasibility of a standard which would use a "combined hazard index," which would include flammability, smoke and toxic gas emissions.

Other DOT Modal Administrations

None of the other Modal Administrations of DOT have promulgated fire safety standards.

5.5 NATIONAL BUREAU OF STANDARDS

Contrary to popular belief, the National Bureau of Standards does not issue standards for flammability. NBS has developed several test procedures which are usually adopted by the consensus standards organizations.

5.6 GUIDELINES

The only known guidelines related to flammability and smoke emission of materials used in ground transportation are the proposed guideline specifications developed at the Transportation Systems Center for the Urban Mass Transportation Administration. These are classified as "proposed" guidelines, and their use is voluntary.

5.7 SPECIFICATIONS

Specifications for the performance of materials are used in the purchase of components, vehicles or systems and are determined by the authority, agency or other body as part of purchase requirements. A specification for a material generally will refer to a

standard test method which must be followed by the supplier. Since the test methods do not set acceptance limits, these are determined by the specification.

Different specifications are applied to specific categories of materials, depending on the type of material, its application, and location in the system.

5.8 RECOMMENDATIONS

Recommendations are generally made by a review board which has investigated a malfunction or an accident, or whose attention has been directed to a hazardous situation. The impact of the recommendation depends on the authority that has been delegated to the review board or to its authoritative character. For example, The Committee on Fire Safety Aspects of Polymeric Materials of the National Materials Advisory Board of the National Academy of Sciences was requested to investigate potential fire hazards of materials used in the railcar of the Washington Metropolitan Transit Authority. Several recommendations were made including the replacement of the polyurethane seat cushions with neoprene foam. This recommendation was implemented by the Authority. Similar recommendations by NBS to the Bay Area Rapid Transit District also resulted in replacement of the seat cushions.

The National Transportation Safety Board makes recommendations following investigation of transportation accidents. There appears to be considerable latitude in the recognition and implementation of these recommendations.

APPENDIX A
BIBLIOGRAPHY OF FIRE SAFETY LITERATURE

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APPENDIX B
SURVEY OF FIRE SAFETY PROJECTS

The compilation of fire safety projects contained herein represents the results of a survey of each of the Department of Transportation Modal Administrations. This survey, conducted during the period Dec. 1977 to June 1978, identified both ongoing and recently completed modal fire safety projects.

OFFICE OF THE SECRETARY OF TRANSPORTATION

TITLE: Development of Protocol and Combustion/Exposure Chamber for Evaluating Combustion Product Toxicity and Smoke Resulting from Burning Transportation Vehicle Interior Materials.

CONTRACT NO.: DOT-OS-60174

FUNDING LEVEL:$60,000 total - Continuing in FY'79

PERFORMING ORGANIZATION:University of Utah

NAME OF PRINCIPAL INVESTIGATOR: William A. Galster

SPONSORING ORGANIZATION: University Research Program

OBJECTIVE: The principal objective of the research is to formulate and evaluate a simplified and meaningful protocol, along with an appropriate combustion and exposure chamber, which will utilize only those parameters and physiological/behavioral effects found to be most relevant in assessing the relative toxicological hazards of burning materials.

DESCRIPTION OF WORK:
(1) Develop exposure chamber, instrumentation and technique.
(2) Subject fabrics to elemental analysis, infrared analysis and thermal analysis.
(3) Conduct in-depth analysis of toxicological characteristics of a fire-retarded material used in transportation.
(4) Evaluate and confirm the repeatability and fidelity of the test protocol.

EXPECTED OUTPUT:
(a) A test protocol, exposure chamber and instrumentation that can be adopted as a standard procedure for toxicity assessment and measurement.

(b) Data on toxic effects of products of combustion particularly CO, HCN, CO_2 SO_2 and H_2S.

DOT FIRE SAFETY R&D

TITLE: Flammability Studies and Toxicological Evaluation of Materials used in Transportation Vehicles.

CONTRACT NO.: DOT-OS-80024

FUNDING LEVEL: $175,000 for two years (July 1976 - July 1978)

PERFORMING ORGANIZATION: The Center for Community Design and Research

NAME OF PRINCIPAL INVESTIGATOR: Carl Sharpe

SPONSORING ORGANIZATION: University Research Program and Office of Environment and Safety.

OBJECTIVE: Development of acceptability criteria for selection of safe materials for the interior of transportation vehicles.

DESCRIPTION OF WORK:

(1) Evaluate and develop flammability test specification.
(2) Test flammability characteristics of representative materials.
(3) Evaluate and develop materials specifications.
(4) Develop a formula for an Acceptability Factor (AP) for materials and validate sample tests with full scale burns.

EXPECTED OUTPUT:

(1) Test-data on a number of non-metallic materials.
(2) Comparative evaluation of these materials based on the hazard index; on AF rating.
(3) Recommendations as to material compositions that provide less hazard to occupants in case of a fire.

DOT FIRE SAFETY R&D

TITLE: System Safety - An Interdisciplinary Approach to Transportation Safety

CONTRACT NO.: DOT-OS-50241

FUNDING LEVEL: $135,000 & 78/79

PERFORMING ORGANIZATION: Polytechnic Institute of New York

NAME OF PRINCIPAL INVESTIGATOR: L. J. Pignataro

SPONSORING ORGANIZATION: University Research Program

OBJECTIVE: To develop a transportation Safety Methodology, apply the methodology to transportation cases and refine the methodology.

DESCRIPTION OF WORK: YEAR 1- Identification and necessary resolution of key issues, and preparation of a draft methodology for the study of transportation system safety.

YEAR 2- Application of methodology as developed in year one. Selection, execution and reporting of case studies.

YEAR 3- Refinement of the methodology, generalization of guidelines and further testing when necessary.

EXPECTED OUTPUT:

(1) Transportation System Safety Methodology
(2) Key issues in Transportation Safety.
(3) Survey and annotated Bibliography.
(4) Case studies in air, rapid rail and highway modes.
(5) Detailed analysis of one mode.
(6) A National Symposium on Transportation Safety.

DOT FIRE SAFETY R&D

TITLE: Transportation Fire Safety

CONTRACT NO.: PPA No. OP-837

FUNDING LEVEL: $95,000 in FY-78

PERFORMING ORGANIZATION: Transportation Systems Center

NAME OF PRINCIPAL INVESTIGATOR: W.T. Hathaway

SPONSORING ORGANIZATION: Office of the Secretary

OBJECTIVE: To develop an integrated program plan for the improvement of fire safety in transportation.

DESCRIPTION OF WORK: The task is to evaluate the current status of fire safety in transportation and the thoroughness with which DOT programs address the fire safety problems. Areas which have multimodal interest and application will receive special attention.

EXPECTED OUTPUT: A report of the evaluation of the present DOT Fire Safety effort with a plan for improving the DOT fire safety program.

FEDERAL AVIATION ADMINISTRATION

DOT FIRE SAFETY R&D

TITLE: Methodology/Criteria to Rank Cabin Material for Total Combustion Hazard

CONTRACT NO.: 181-521-7

FUNDING LEVEL: $75,000 (Phase I)

PERFORMING ORGANIZATION: McDonnell/Douglas Aircraft Co.

NAME OF PRINCIPAL INVESTIGATOR:

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: To support regulatory process for improved cabin fire safety.

DESCRIPTION OF WORK: Development of Combined Hazard Index (CHI)

3 Phases:

1. Analyze and describe detail plan for development of methodology.
2. Develop method for establishing CHI for materials.
3. Demonstrate/validate the CHI method.

EXPECTED OUTPUT: Final report, Phase I, Jan., 1978.

DOT FIRE SAFETY R&D

TITLE: Method to Assess Flash Fire Propensity of Cabin Materials

CONTRACT NO.: 181-521-4

FUNDING LEVEL: N/A

PERFORMING ORGANIZATION: NAFEC/N.B.S.

NAME OF PRINCIPAL INVESTIGATOR: C. Huggett (NBS)

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: To support technical basis for improved flammability standards-cabin materials.

DESCRIPTION OF WORK: Develop and demonstrate laboratory equipment and procedure for assessing interior materials for flash fire propensity.

EXPECTED OUTPUT: Final report 12/77.

DOT FIRE SAFETY R&D

TITLE: Improve Transport Aircraft Emergency Lighting

CONTRACT NO.: 181-521-9

FUNDING LEVEL: N/A

PERFORMING ORGANIZATION: NBS/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: S.A. Mangiapane, (Prog. Mgr.)

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: Upgrading emergency interior lighting criteria for transport aircraft.

DESCRIPTION OF WORK: During full-scale burn tests using C-133 test facility at NAFEC (ref. Project 181-521-OPX) evaluate performance of emergency interior cabin lighting and exit marking standards under adverse conditions, i.e., dark night and black smoke. Determine whether addition of floor-level lighting system or other lighting/marking concepts improves exit conspicuity.

EXPECTED OUTPUT: Final report 10/78.

DOT FIRE SAFETY R&D

TITLE: General Aviation Crash Resistant Fuel System

CONTRACT NO.: 184-521-3

FUNDING LEVEL: $180,000

PERFORMING ORGANIZATION: FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: J. Sommers

SPONSORING ORGANIZATION: FAA/ARD-520 (H. Spicer)

OBJECTIVE: AFS, in their need for data to help them improve the crashworthiness at general aviation air plane fuel containment through the test demonstration of crash-resistant tank technology.

DESCRIPTION OF WORK:

EXPECTED OUTPUT: Final Report, 6/78.

DOT FIRE SAFETY R&D

TITLE: Develop Cabin Fire Safety Criteria

CONTRACT NO.: 181-521-10X

FUNDING LEVEL: $200,000 (Contractor)

PERFORMING ORGANIZATION: FAA (NAFEC)

NAME OF PRINCIPAL INVESTIGATOR: C. Sarkos

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: To support regulatory process for improving cabin safety.

DESCRIPTION OF WORK:

1. Develop C-133 Cabin fire test facility
2. Determine cabin environment-external fire
3. Define cabin hazards-internal materials involvement
4. Technical Support (Chem. lab) for full-scale tests
5. Dev. laboratory tests/correlation/full scale five
   a. Evaluate existing flam. test methods
   b. Extend test range of NBS Smoke Chamber
   c. Interim method for ranking materials for toxicity
6. Develop a scale cabin fire modeling technique
7. Interim human tolerance limits-(cabin fire) CAMI
8. Validation tests: CHI and math. modeling.

EXPECTED OUTPUT: Final report, June, 1980.

DOT FIRE SAFETY R&D

TITLE: Modified Fuel

CONTRACT NO.: 181-520-1

FUNDING LEVEL: $65,000 (FY 78)

PERFORMING ORGANIZATION: FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: J. Van Dyke (Prog. Mgr.)

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: To support regulatory standards that would require aviation fuels to contain an anti-misting additive that will reduce or eliminate the fine mist which becomes a fire ball when fuel is released during an impact survivable crash and subsequently envelops an aircraft and ignites the pool of fuel and inter cabin materials, often precluding safe evacuation.

DESCRIPTION OF WORK:

EXPECTED OUTPUT: Final report to be delivered to AFS-1 1/78.

TITLE: Method to Assess Fire Characteristics of Transport Cabin

CONTRACT NO.: 181-521-1

FUNDING LEVEL: $334,003

PERFORMING ORGANIZATION: FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: C. Troha, (Prog. Mgr.)

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: Support model predictive technique to aid in regulatory process.

DESCRIPTION OF WORK: (1) Develop math model of cabin/lavatory fires which accounts for: (a) elements of interior materials and structure; (b) smoke, gas, thermal emissions due to combustion of these elements; (c) distribution characteristics of effluents of combustion of elements; (2) measure the combustion characteristics of associated cabin-lavatory materials using laboratory apparatus; (3) integrate laboratory test data into computer program; and (4) verify/refine math model utilizing available cabin/lav. fire test data.

EXPECTED OUTPUT: Final report 1/78.

TITLE: Develop Toxic Gas Emissions Criteria for Cabin Interior Materials

CONTRACT NO.: 181-521-5

FUNDING LEVEL: $20,000

PERFORMING ORGANIZATION: FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: J. Spurgeon

SPONSORING ORGANIZATION: FAA/ARD-520

OBJECTIVE: Integrate NAFEC/CAMI test reports- Toxic Gas Emissions Criteria.

DESCRIPTION OF WORK:

EXPECTED OUTPUT: Final Report 12/77.

DOT FIRE SAFETY R&D

TITLE: Flammability Testing of Materials

CONTRACT NO.: RA: 76-4 Mod#1 611-0349

FUNDING LEVEL: $33,750 (FY77 and FY78)

PERFORMING ORGANIZATION: FAA/NAFEC

FTS PHONE: 8-346-0200
EX: 3574

NAME OF PRINCIPAL INVESTIGATOR: G. Sarkos

SPONSORING ORGANIZATION: UMTA/TSC

OBJECTIVE: Provide reliable fire-safety data on selected materials for transit systems.

DESCRIPTION OF WORK: Testing of flammability and smoke emissions of materials provided by DTS-332.

EXPECTED OUTPUT: Data for inclusion in UMTA data bank.

TITLE: USAF Fire Protection Program

CONTRACT NO.: MIPR FY 1455-78-00603; Agreement NA-168

FUNDING LEVEL: $115,000

PERFORMING ORGANIZATION: Aircraft & Airports Safety Div., Fire Safety Br., ANA-420 FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: G. Chamberlain

SPONSORING ORGANIZATION: USAF, WPAFB, Ohio, AFAPL/SFH

OBJECTIVE. Improvement of aircraft fire safety.

DESCRIPTION OF WORK:

L. Select suitable replacement fire extinguishing agent for bromochloromethane (CB) for aircraft habitable compartments.

2. Determine feasibility of using intumescent coatings for the improvement of fire resistance of self-sealing fuel lines.

3. Improvement of fire hardening, detection and control for high performance aircraft.

EXPECTED OUTPUT:

1. Recommended replacement extinguishant for CB (Report)

2. Recommendation as to the feasibility of using intumescent coatings to improve fire resistance of fuel lines (Report)

3. Recommendations for the improvement of fire hardening, detection, and control for high performance aircraft (Report).

TITLE: Habitable Inert Atmosphere Using Carbon Tetrafluoride (Halon 1400)

CONTRACT NO.: 910-003-300 Agreement #295

FUNDING LEVEL: $55,000

PERFORMING ORGANIZATION: Aircraft & Airports Safety Div., Fire Safety Br., ANA-420, FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: L.M. Neri (G. Geyer)

SPONSORING ORGANIZATION: U.S. Air Force, DET 1 Hq. ADTC/CNE, Tyndall AFB, Florida

OBJECTIVE: To establish the feasibility of replacing a potentially lethal aircraft interior environment with a cool habitable atmosphere which is nonsupporting of combustion during evacuation in fire emergencies.

DESCRIPTION OF WORK: Design and test a crash-fire-rescue (CFR) vehicle/system capable of producing a habitable atmosphere by proportioning Halon 1400 into a moving airstream. The cool inert atmosphere produced by a centrifugal fan will be discharged into the aircraft interior through suitable flexible ducts to sweep out the hot toxic atmosphere during an aircraft fire emergency.

Full-scale fire modeling experiments will be conducted in a DC-7 to establish the atmospheric flow rates required to develop and maintain a habitable fuselage environment in realistic fire test configurations.

EXPECTED OUTPUT: A final report describing a new highly specialized CFR vehicle for extinguishing aircraft cabin fires, and means of providing a cool habitable atmosphere for passengers during evacuation in fire emergencies.

TITLE: Evaluate the Aircraft Skin Penetrator Nozzle for Cabin Fire Protection

CONTRACT NO.: NPD 08-472; Subprogram 081-431-120

FUNDING LEVEL: $20,000

PERFORMING ORGANIZATION: Aircraft & Airports Safety Div., Fire Safety Br., ANA-420, FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: J. O'Neill (G. Geyer)

SPONSORING ORGANIZATION: ARD-420

OBJECTIVE: To determine the firefighting effectiveness of the U.S. Air Force Aircraft skin penetrator nozzle in extinguishing Class A and Class B cabin fires with foam-water/fog provided by the crash-fire-rescue (CFR) services from an external source of supply.

DESCRIPTION OF WORK: Fire harden the interior cabin of a DC-7 aircraft to contain a fireload of sufficient size to provide a thermally uninhabitable environment in 1/4 to 1/3 of the total volume of the cabin in approximately 90 seconds after fuel ignition. Establish the optimum nozzle configuration and the ballistic charge required to penetrate the fuselage skin of the test bed aircraft at various critical points of entry within the passenger cabin. Determine the nozzle orifice configuration required to obtain the maximum flow rate of each agent, and the optimum distribution pattern and density within the cabin interior.

EXPECTED OUTPUT: A final technical report presenting an assessment of the feasibility and procedures for employing the aircraft skin penetrator nozzle to combat interior aircraft cabin fires.

TITLE: Evaluate Firefighting Agents, Equipment, Systems, and Techniques

CONTRACT NO.: NPD 08-472; Subprogram 081-431-110

FUNDING LEVEL: $100,000

PERFORMING ORGANIZATION: Aircraft & Airports Safety Div., Fire Safety Br., ANA-420, FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: G.B. Geyer

SPONSORING ORGANIZATION: ARD-420

OBJECTIVE: To provide effective aircraft firefighting and rescue capabilities at airports.

DESCRIPTION OF WORK: Conduct laboratory and full-scale fire modeling experiments with all nationally and internationally available, firefighting foams, and rank these agents according to their firefighting effectiveness. Determine the most effective firefighting techniques applicable to each of the three classes of firefighting foams, i.e., Aqueous-Film-Forming-Foams (AFFF), Fluoroprotein Foam and Regular Protein Foam.

EXPECTED OUTPUT: A final technical report presenting the results of laboratory and full-scale fire modeling experiments of value to airport operators, fire Chiefs and research/educational organizations. Additionally, the report will provide a data base for assessing the optimum foam fire extinguishing agents, quantities and application techniques for airports.

TITLE: Full-Scale Fire Modeling Tests of a Compact Rapid Response Foam and Dry Chemical Powder Dispensing System

CONTRACT NO.: NPD 08-472; Subprogram 081-431-160

FUNDING LEVEL: $50,000

PERFORMING ORGANIZATION: Aircraft & Airports Safety Div., Fire Safety Branch, ANA-420 FAA/NAFEC

NAME OF PRINCIPAL INVESTIGATOR: G.B. Geyer

SPONSORING ORGANIZATION: ARD-420

OBJECTIVE: To develop a rapid response skid/trailer mounted firefighting system capable of dispensing dry chemical powder or foam, either singly or in combination.

DESCRIPTION OF WORK: Evaluate a twinned foam-powder dispensing system in terms of each agent alone and in combination and establish the equivalency of the agents against a dual agent discharge on full-scale Jet A fuel fires.

EXPECTED OUTPUT: A final technical report presenting data and an assessment of the firefighting equivalency of dry chemical powder in terms of Aqueous-Film-Forming-Foam (AFFF) on full-scale Jet A fuel fires and the increased/decreased advantages in using the combined foam-powder discharge over a single agent application.

DOT FIRE SAFETY R&D

TITLE: Inhalation Toxicity of the Irritant Gases HCL, NO_2, and SO_2.

CONTRACT NO.: AM-78-TOX36

FUNDING LEVEL: $90,000

PERFORMING ORGANIZATION: CAMI

NAME OF PRINCIPAL INVESTIGATOR: Dr. Charles R. Crane

SPONSORING ORGANIZATION: FAA/OAM (Office of Aviation Medicine Funding)

OBJECTIVE: To determine the toxicity - in terms of the incapacitation and lethal doses for the albino rat - of each of the three irritant gases hydrogen chloride, nitrogen dioxide, and sulfur dioxide.

DESCRIPTION OF WORK: Rats will be exposed in the CAMI Inhalation Toxicity Apparatus to known concentrations of each of the subject gases and the times - to - incapacitation and the death will be determined. The exposures will be repeated a sufficient number of times, and at a sufficient number of different concentrations, to allow the statistical definition of the incapacitating dose and the lethal dose for each of these gases.

EXPECTED OUTPUT: Results of these tests are required in order that the individual contribution for each gas to the total toxicity of a mixture of combustion gases may be assessed. Such information could then be used to establish tolerance limits for each gas in a fire environment, and in this way aid in the selection of polymeric materials used in transportation vehicles to improve the potential for escape and survival in the event of a fire.

DOT FIRE SAFETY R&D

TITLE: Toxicity of Combustion Products of Transit Materials

CONTRACT NO.: (RA) 77-16

FUNDING LEVEL: $50,000

PERFORMING ORGANIZATION: CAMI

NAME OF PRINCIPAL INVESTIGATOR: Dr. Charles Crane

SPONSORING ORGANIZATION: UMTA/TSC

OBJECTIVE: To determine the toxicity of products of combustion of various types of materials used in urban rail systems.

DESCRIPTION OF WORK: Live animals (rats) are exposed to gases evolved from materials used in rail transit vehicles, such as electrical insulation. The times to incapacitation and times to death are determined.

EXPECTED OUTPUT: Results of these tests will be used to determine the toxicity of the products of combustion to humans. These results will be combined with results of flammability tests on electrical insulation, performed under contract by Boeing Commercial Airplane Co., to provide a total comparison of flammability properties.

TITLE: Inhalation Toxicology of the Combustion Products of New, State-of-the-Art, Polymeric Materials.
CONTRACT NO.: AM-78-TOX38

FUNDING LEVEL: $60,000

PERFORMING ORGANIZATION: CAMI

NAME OF PRINCIPAL INVESTIGATOR: Dr. Charles R. Crane

SPONSORING ORGANIZATION: FAA/OAM (Office of Aviation Medicine Funding)

OBJECTIVE: To evaluate the toxicity of the thermal degradation products of new, advanced technology, synthetic polymers relative to that of materials in current usage.

DESCRIPTION OF WORK: Appropriate materials will be thermally decomposed under defined thermal conditions. The toxicity of the resultant volatile products will be determined by the CAMI Combustion Toxicology protocol which is based on the measurement of time to incapacitation of albino rats exposed to the toxic atmosphere.

EXPECTED OUTPUT: Results of these tests will be used to maintain the currency of a file describing the relative merits (based on potential toxicity) of polymeric materials that are either currently used in the transportation industry or have a potential for future use. This information will provide a mechanism for the informed selection (or replacement) among several candidate materials for a specific end - use to insure that the hazard from exposure to toxic combustion products is minimized in the transportation industry.

URBAN MASS TRANSPORTATION ADMINISTRATION

TITLE: Fire Safety Evaluation of Automated Guideway Transit Vehicles

CONTRACT NO.: DOT-AT-70025

FUNDING LEVEL: $20,000

PERFORMNG ORGANIZATION: Center for Fire Research, National Bureau of Standards

NAME OF PRINCIPAL INVESTIGATOR: R. D. Peacock

SPONSORING ORGANIZATION: UMTA, UTD-50

OBJECTIVE: To explore and formulate the fire safety guidelines to be required for automated vehicles used for the movement of people in congested urban areas.

DESCRIPTION OF WORK: By the review of existing systems similar to those that are expected to be used in the "Downtown People Mover" (DPM) program, scenarios will be developed in order to establish the maximum and minimum levels of fire safety of the vehicles for several types of DPM systems. In addition to the methods and materials of construction, the interior finish materials, the means of fire detection and/or suppression, size, accessibility and operations environment will be considered when proposing fire safety guidelines.

By comparing them to the standards being used in other modes of transportation, using available test methods, the most relevant rationalc for establishing guidelines will be developed.

EXPECTED OUTPUT: A final report will be prepared describing the effort and presented to the manufacturers and operators in a workshop environment.

DOT FIRE SAFETY R&D

TITLE: Computerized Materials Information Bank

CONTRACT NO.: DOT-TSC-1534

FUNDING LEVEL: $ 58,198

PERFORMING ORGANIZATION: Boeing Commercial Airplane Co.

NAME OF PRINCIPAL INVESTIGATOR: J. Peterson

SPONSORING ORGANIZATION: UMTA through TSC, PPA UM-21

OBJECTIVE: Updating and maintenance of UMTA's material data bank.

DESCRIPTION OF WORK:

1. Addition of materials categories and insertion of metric equivalents
2. Addition of new materials data and correction of old data.

EXPECTED OUTPUT: A revised and updated materials data bank for reference in specifying materials for transit system.

TITLE: Fire Safety In Transit Systems

CONTRACT NO.: PPA UM-21

FUNDING LEVEL: $215,000

PERFORMING ORGANIZATION: TSC/DOT

NAME OF PRINCIPAL INVESTIGATOR: W.T. Hathaway

SPONSORING ORGANIZATION: UMTA

OBJECTIVE: To assess the overall fire threat in transit systems and to identify and recommend suitable remedial actions. These remedial actions shall be designed to minimize and, where possible, eliminate the fire threat in transit systems.

DESCRIPTION OF WORK: This project then involves assessing the present fire safety efforts and then identifying, through the use of scenarios, the fire threat in transit systems. Having identified the fire threats, countermeasures designed to eliminate or minimize this fire threat may then be proposed. Resulting from these countermeasures will be proposed standards and prospective R&D projects to evaluate or implement the proposed standards.

EXPECTED OUTPUT: A better understanding of the fire threat in transit systems and a means for eliminating or minimizing this fire threat.

DOT FIRE SAFETY R&D

TITLE: Study of Electrical Insulation

CONTRACT NO.: DOT-TSC-1221

FUNDING LEVEL: $ 116,707

PERFORMING ORGANIZATION: Boeing Commercial Airplane CO.

NAME OF PRINCIPAL INVESTIGATOR: J. York/L. Myer

SPONSORING ORGANIZATION: UMTA

OBJECTIVE: To determine whether any of the currently used electrical insulations can provide a fire-safe environment in terms of low flame propagation, smoke and toxic gas emission.

DESCRIPTION OF WORK:

1. Review standard test method for flammability of wire and cable insulation and select most appropriate for transit system.
2. Review standard test methods for smoke emission and select one for measurement of smoke emission from wire and cable.
3. Select method for measurement of wire circuit integrity.
4. Evaluation candidate electrical insulation by selected procedures.
5. Rank insulation according to test results.

EXPECTED OUTPUT: Results will be useful improving the fire safety of transit vehicles.

FEDERAL RAILROAD ADMINISTRATION

TITLE: Rail Car Material Evaluation

CONTRACT NO.:

FUNDING LEVEL: $8,400

PERFORMING ORGANIZATION: TSC

NAME OF PRINCIPAL INVESTIGATOR: I. Litant/DTS-332

SPONSORING ORGANIZATION: FRA

OBJECTIVE: 1. Review of materials specifications and evaluation for AMTRAK

2. Test and evaluation of selected materials

3. Monitoring of ongoing and proposed studies of PCB transformer retrofill

DESCRIPTION OF WORK:

1. Assistance is provided to FRA and AMTRAK in reviewing materials (non-metallic) used in AMTRAK vehicles.

2. Co-monitoring of contracts concerning the replacement of arochlors in transit transformers.

EXPECTED OUTPUT:

1. The review of materials is an ongoing project and is provided on an as-required basis. Information on new materials is provided to AMTRAK design personnel.

2. Recommendations will be made to FRA concerning the efficiency of retrofilling arochlor-filled transit transformers.

TITLE: Rail Hazardous Material Tank Car Torching Study and Pool Fire Test (Phase V)

CONTRACT NO.: AR-44061

FUNDING LEVEL: $350,000

PERFORMING ORGANIZATION: U.S. Army Ballistic Research Laboratories

NAME OF PRINCIPAL INVESTIGATOR: Ed. Baicy

SPONSORING ORGANIZATION: FRA

OBJECTIVE: Develop Guidelines and/or specifications for the thermal protection of tank cars subjected to torch fires.

DESCRIPTION OF WORK:

1. Comparison testing of selected insulation systems - conduct 16 tests on 2 insulation jacket thermal shield materials to determine

   (a) Repeatibility in various torch fire facilities
   (b) Correlation between data results obtained from different torch fire facilities
   (c) Effect of density

2. Conduction of 2 full scale torch fires-one-tank-car with no protection; one car with an insulated jacket.

EXPECTED OUTPUT:

1. Test methodology for evaluating thermal shield materials

2. Determination of effect of density on thermal shield effectiveness.

TITLE: FIRE SAFETY CONCEPTS FOR RAILROAD CARS CARRYING CLASS A EXPLOSIVES

CONTRACT NO.: AR-8198

FUNDING LEVEL: $125,000

PERFORMING ORGANIZATION: NATIONAL BUREAU OF STANDARDS

NAME OF PRINCIPAL MONITOR: DAVE DANCER

SPONSORING ORGANIZATION: FRA

OBJECTIVE: Reduce the frequency/severity of fires in RR cars carrying Class A explosives.

DESCRIPTION OF WORK: (1) Determine the performance requirements of spark shields and fire detection/suppression systems.

EXPECTED OUTPUT: Performance specs for spark shields and fire detection/suppression systems. A test plan for full scale and/or small scale fire tests.

TITLE: NEUTRALIZATION AND CONTROL OF SPILLS FROM RAILROAD TANK CARS

CONTRACT NO.: P.O. 8204

FUNDING LEVEL: $9,969

PERFORMING ORGANIZATION: GEO-CENTERS

NAME OF PRINCIPAL MONITOR: DAVE DANCER

SPONSORING ORGANIZATION: FRA

OBJECTIVE: Mitigate the effects of RR chemical spills.

DESCRIPTION OF WORK:

1. The contractor shall review the various methods and techniques for controlling and inhibiting the flammability/explosibility/detonability and toxicity from chemical spills. These shall include, but not be limited to, cloud dispersal and initiation and the use of additives to reduce and inhibit the deflagation, detonation, and toxicity threat.

2. The contractor shall perform a preliminary analysis on cloud dissipation techniques (laser, sparks, high explosives, ultra-violet light) which could be used to dissipate, neutralize, and inhibit the threat from chemical clouds resulting from spills that present toxic dangers. Some of these dissipation techniques can be employed remotely, thus they are attractive from a safety viewpoint.

3. The contractor shall recommend laboratory and field tests that would corroborate the results obtained in Tasks 1 and 2 above.

EXPECTED OUTPUT: Techniques for the emergency response to RR chemical spills.

RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION

DOT FIRE SAFETY R&D

TITLE: Fire Tests on Drums

CONTRACT NO.: DOT-AS-60071

FUNDING LEVEL: $21,800 from MTB/OHMO & Funds from U.S.C.G.

PERFORMING ORGANIZATION: U.S. Coast Guard

NAME OF PRINCIPAL INVESTIGATOR: G. J. Monkenbeck

SPONSORING ORGANIZATION: MTB/OHMO joint with U.S. Coast Guard

OBJECTIVE: To determine the comparative behavior of plastic versus metallic drums (with metal and with plastic bungs) in a fire situation.

DESCRIPTION OF WORK: Both plastic and metal specification drums, filled with a flammable liquid, were cooked in an open fire and the behavior observed.

EXPECTED OUTPUT: Information is valuable to emergency response personnel for assessing the hazards of such packaging at the accident scene. The data are valuable for reviewing the packaging safety integrity criterion 49 CFR and assisting in rulemaking relative to the possible revision of these Regulations.

DOT FIRE SAFETY R&D

TITLE: Classification of Spontaneously Combustible Materials

CONTRACT NO.: DOT-AS-40049

FUNDING LEVEL: $68,100 - Started FY74 On-going Program

PERFORMING ORGANIZATION: Naval Surface Weapons Center (White Oak, MD)

NAME OF PRINCIPAL INVESTIGATOR: Mr. Harry Weaver

SPONSORING ORGANIZATION: MTB/OHMO (DMT-10)

OBJECTIVE: To develop test methods and related criteria for classification of spontaneously combustible materials (other than pyrophorics) for transportation technical basis for updating Title 490 FR.

DESCRIPTION OF WORK: The work involves developing a calorimetric method for determining those materials which over a period of time may reach an auto ignition temperature without external ignition source in the transportation system. Selected materials are being tested to validate the method. The project is ongoing.

EXPECTED OUTPUT: A standardized test method and related classifications criteria which can form the technical basis for revising the corresponding section of the DOT HM Regulations (Title 490 FRI). Results will be useful in evaluating exemption petitions and supporting surveillance, compliance efforts and investigations.

TITLE: Development of a Training Course to Enable Emergency Services to Handle Hazardous Materials Transportation Incidents

CONTRACT NO.: DOT-OS-60502

FUNDING LEVEL: $168,532 Total Funding (FY 1976-78)

PERFORMING ORGANIZATION: National Fire Protection Association, Boston, MA

NAME OF PRINCIPAL INVESTIGATOR: Mr. Arestin Sennett

SPONSORING ORGANIZATION: MTB/OHMO (DMT-10)

OBJECTIVE: To provide a 20-hr. self-standing course which will provide the emergency services personnel with the guidance necessary for developing a viable community action plan for assessing the situation and effectively dealing with any transportation incidents.

DESCRIPTION OF WORK: NFPA has developed an 8-unit slide, tape, instructor's manual and student workbook combination which is highly interactive and of about 20 hour duration. It was field tested on 3 occasions in the field during development. Project is completed.

EXPECTED OUTPUT: Several complete course packages to be delivered to OHMO. OHMO is developing a distribution plan. NFPA plans to market the course packages and put on a number of regional seminars.

TITLE: Classification of Oxidizers and Flammable Solids

CONTRACT NO.: DOT-AS-30042

FUNDING LEVEL: $124,815 Started FY-73 - On-going Program

PERFORMING ORGANIZATION: Naval Ordnance Station, Indian Head, MD

NAME OF PRINCIPAL INVESTIGATOR: Dr. Charles B. Nile

SPONSORING ORGANIZATION: OHMO (DMT-10)

OBJECTIVE: To develop test methods and related criteria for classification of oxidizing materials and flammable solids for transportation Technical basis for updating Title 49 CFR.

DESCRIPTION OF WORK: The work involves validating and modifying proposed methods for determining the hazards of gaseous, liquid and solid oxidizers and flammable solids for classification and resultant packaging selection. Selected materials are tested also on an "as needed" basis. Project is ongoing.

EXPECTED OUTPUT: Standardized test methods and related classification criteria which can form the technical basis for revising the corresponding section of the DOT Hazardous Materials Regulations (Title 490 FR). Results are also useful for emergency response purposes. Data which enable decisions on exemption petitions and provide compliance and investigation support also result.

DOT FIRE SAFETY R&D

TITLE: Evaluation of Mattress Materials for Coast Guard Cutters

CONTRACT NO.: # 70099-7-74380

FUNDING LEVEL: $16,000

PERFORMING ORGANIZATION: National Bureau of Standards

NAME OF PRINCIPAL MONITOR: T. P. Brandsma and M. Friel

SPONSORING ORGANIZATION: U.S. Coast Guard (G-CSP)

OBJECTIVE: Evaluate fire hazard of mattresses used or proposed for Coast Guard cutters.

DESCRIPTION OF WORK:
Three neoprene mattresses and one polyurethane mattress were tested in full-scale simulated bunk spaces. The spaces were instrumented for temperature, weight, heat flux, smoke, and gas concentrations. The three neoprene mattresses consisted of a used black foam mattress removed from a vessel, a new black foam mattress from a warehouse and a new buff foam mattress which had recently been developed with the intent of reducing smoke production.

Newspaper was used to ignite pillow and mattress. Test duration was 30 minutes.

EXPECTED OUTPUT:
None of the neoprene mattresses was significantly consumed before termination of test. About 50% of urethane mattress was consumed. Maximum temperatures for the used neoprene mattress and the polyurethane mattress were higher than for the other mattresses, which would not even have operated a sprinkler head.

Gas concentration from the polyurethane mattress was high. The buff neoprene mattress exhibited superior smoke reduction.

DOT FIRE SAFETY R&D

TITLE: Development of Lightweight High Capacity Transportable Fire Fighting Module

CONTRACT NO.: DOT CG 60,567

FUNDING LEVEL: $270,000 (CG share)

PERFORMING ORGANIZATION: NASA

NAME OF PRINCIPAL MONITOR: E.H. Bonekemper

SPONSORING ORGANIZATION: U.S. Coast Guard (G-WLE) & NASA

OBJECTIVE: Develop lightweight firefighting module that can be easily transported by aircraft or utility boat to the scene of major marine fires.

DESCRIPTION OF WORK: A small, lightweight unit using a jet engine and pump has been developed and tested. Improvements are now being made to reliability. Unit will contain pump capable of several thousand gpm at 100-200psi, hose, monitor, suction pipe, and accessories.

EXPECTED OUTPUT: Firefighting module

DOT FIRE SAFETY R&D

TITLE: Flammability Tests of Drapes and Curtains

CONTRACT NO.: 819301

FUNDING LEVEL: $20,000

PERFORMING ORGANIZATION: National Bureau of Standards

NAME OF PRINCIPAL INVESTIGATOR: A. F. Robertson

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Develop international fire test for drapes and curtains

DESCRIPTION OF WORK: Tests of various nations for flammability of drapes and curtains are being evaluated. A suitable apparatus has been identified and tests are being conducted to measure reliability and reproduceability.

EXPECTED OUTPUT: A single uniform international test for flammability of drapes and curtains.

DOT FIRE SAFETY R&D

TITLE: Fire Safety Aboard LNG Vessels

CONTRACT NO.: DOT - CG - 42,355A, Task 1

FUNDING LEVEL: $150,000

PERFORMING ORGANIZATION: University Engineers Inc.

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Examination of cargo spill and fire hazard potential associated with the marine handling of liquefied natural gas (LNG) cargo.

DESCRIPTION OF WORK: Statistical analysis of failure incidents. Fault tree analysis of LNG tanker cargo and hazard control systems.

Calculation of magnitudes of potential hazards.
Estimation of on-site risk of fire fatality.
Calculation of fire control capabilities.

EXPECTED OUTPUT: Published U.S. regulations and codes and foreign codes do not now specify protection and prevention systems which would provide a tolerate level of risk (10^{-10} fire fatalities per hour exposure). However, most LNG tankers have considerably more protection than is now required in anticipation that proposed fire regulations will be retroactively applied.

DOT FIRE SAFETY R&D

TITLE: Fire Testing of Lightweight Wall Panels

CONTRACT NO.: # 70,099-6-7 1043

FUNDING LEVEL: $54,000

PERFORMING ORGANIZATION: Naval Weapons Center, China Lake

NAME OF PRINCIPAL MONITOR: K.D. Terry

SPONSORING ORGANIZATION: U.S. Coast Guard (G-ENE)

OBJECTIVE: Evaluate behavior of lightweight honeycomb wall panels in a large scale fire test.

DESCRIPTION OF WORK: 14' x 14' Rooms were built using lightweight aluminum wall panels, lightweight nomex wall panels, and standard marine joiner construction. A 20,000 BTU/min propane burner was used to simulate a well involved fire. The results were compared to tests under similar conditions of standard marinite panels.

EXPECTED OUTPUT: Data on the viability of lightweight honeycomb wall panels as a substitute for marinite which has a 30 minute or longer fire resistance.

TITLE: Marine Firefighting Program

CONTRACT NO.: None-furnished material

FUNDING LEVEL: $7,000

PERFORMING ORGANIZATION: Eleventh Coast Guard District

NAME OF PRINCIPAL INVESTIGATOR: L. J. MCPOLIN

SPONSORING ORGANIZATION: U.S. Coast Guard (D)

OBJECTIVE: Establish an initial Marine Fire Fighting Program utilizing Coast Guard reservists who are professional municipal firefighters. Form Firefighting strike teams to assist vessels having fires at sea.

DESCRIPTION OF WORK: This is a pilot program in which professional fire fighters who are Coast Guard reservists have been formed into 3 firefighting strike teams. The teams have received specialized training in shipboard firefighting and are prepared to aid vessels having fires at sea. A training plan has been developed. A limited amount of equipment has been provided for use by these teams.

EXPECTED OUTPUT: Information on cost and organization of firefighting strike teams that could eventually be set up in major port areas.

DOT FIRE SAFETY R&D

TITLE: Electric Cables for ships - Standards of performance and Test Specifications

CONTRACT NO.: Z - 70099-74285

FUNDING LEVEL: $200,000

PERFORMING ORGANIZATION: Todd Shipyard, Seattle Div. and Batelle

NAME OF PRINCIPAL MONITOR: R. M. Dent

SPONSORING ORGANIZATION: U.S, Coast Guard (G-MMT) and MARAD

OBJECTIVE: Develop a performance standard and test specification for electric cable on ships. Fire performance is to be a part of this specification.

DESCRIPTION OF WORK: Survey existing cable and test data. New types of cable are to be fire tested.

Develop recommendations for determining the properties of electric cable

EXPECTED OUTPUT: Specification

DOT FIRE SAFETY R&D

TITLE: Vapor cloud Explosion Study

CONTRACT NO.: MIPR-CG-34, 094-A

FUNDING LEVEL: $900,000

PERFORMING ORGANIZATION: Naval Weapons Center, China Lake

NAME OF PRINCIPAL MONITOR: A.L. Schneider

SPONSORING ORGANIZATION: USCG(G-MHM). Additional Phase II and IV funding from ERDA, AGA, OPSO, NASA, DOE

OBJECTIVE: To determine the hazards created by the release of large quantities of flammable cryogens.

DESCRIPTION OF WORK: Initial work has centered on LNG vapor clouds including shock tube tests, 5 and 10 meter radius hemisphere tests and upcoming spills on water

EXPECTED OUTPUT: A scientific analysis of the factors necessary to create an unconfined detonation in the vapor cloud resulting from the spill of a flammable, cryogenic cargo. Evaluation of the factors will yield a better risk assessment technique for future C.G. regulations.

DOT FIRE SAFETY R&D

TITLE: Class A fire extinguisher tests

CONTRACT NO.: 824313

FUNDING LEVEL: $5,000

PERFORMING ORGANIZATION: Underwriters Laboratories,NFPA

NAME OF PRINCIPAL MONITOR: Klaus Wahle

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Determine if NFPA Classification and UL approvals of 2A fire extinguishers are equally acceptable with untrained persons.

DESCRIPTION OF WORK: Untrained operators are to be used for all tests of class A fire extinguishers. Identical fires are to be extinguished using water, foam, dry chemical, and halon to determine the minimum amount of each agent capable of extinguishing fires with a novice operator.

The NFPA 10 committee on portable extinguishers will evaluate the results.

EXPECTED OUTPUT: Verify or revise existing rating and testing requirements for Class A portable fire extinguishers.

DOT FIRE SAFETY R&D

TITLE: Chemical Cargo Fire Protection

CONTRACT NO.: CG-42,355

FUNDING LEVEL: $400,000

PERFORMING ORGANIZATION: Applied Technology Corporation

NAME OF PRINCIPAL MONITOR: D. F. Sheehan/M. Query

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT) and (G-MHM)

OBJECTIVE: To provide design data for engineering fire protection systems for hazardous cargoes.

DESCRIPTION OF WORK: Develop a standardized test procedure to evaluate available fire extinguishing agents on fires of hazardous materials.

EXPECTED OUTPUT: A matrix of agents vs. cargoes providing application quantities and rates which will allow extrapolation to new cargo. A standard test method to compare new agents with existing agents.

DOT FIRE SAFETY R&D

TITLE: Compartment Burnout Tests.

CONTRACT NO.: 3308.5.2

FUNDING LEVEL: $254,300

PERFORMING ORGANIZATION: USCG R&D Center

NAME OF PRINCIPAL INVESTIGATOR: R.C. Richards

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Evaluate the effect of changes in construction and furnishing materials on the fire performance of compartments.

DESCRIPTION OF WORK: Several furnished compartments are to be burned out. Ventilation rates are to be varied to determine their effect. Modern contents are to be compared to contents tested in similar tests approximately 30 years ago.

Modeling studies will be examined to determine if small scale models can accurately predict the performance of large scale compartments.

EXPECTED OUTPUT: The results should aid in determining the need for revising the fire resistance requirements of bulkheads and decks, the need to revise the time-temperature curve, or the need to limit the fuel load of certain materials.

DOT FIRE SAFETY R&D

TITLE: Cargo Hold Extinguishment with CO_2

CONTRACT NO.: 3308.5.4

FUNDING LEVEL: $119,900

PERFORMING ORGANIZATION: USCG R&D Center

NAME OF PRINCIPAL INVESTIGATOR: R.C. Richards

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Evaluate the parameters necessary for successful extinguishment of large scale Class A fires with carbon dioxide.

DESCRIPTION OF WORK: Preliminary work has evaluated on a small scale the difficulty to extinguish fires involving various Class A materials. Large scale tests will be conducted on compressed cardboard, which the small scale tests found to be a good example of a hard-to-extinguish fire.

Parameters such as concentration, discharge rate, nozzle placement, etc. will be evaluated.

EXPECTED OUTPUT: It is expected that these tests will either verify the acceptability of existing regulations for CO_2 systems or show how regulations need to be revised.

DOT FIRE SAFETY R&D

TITLE: Cargo Hold Extinguishment with Halon 1301

CONTRACT NO.: 3308.5.6

FUNDING LEVEL: $85,100

PERFORMING ORGANIZATION: USCG R&D Center

NAME OF PRINCIPAL INVESTIGATOR: R.C. Richards

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Evaluate the ability of Halon 1301 to safely extinguish large fires involving Class A material.

DESCRIPTION OF WORK: Halon 1301 is to be discharged into a cargo hold containing burning cardboard to determine the concentration and discharge time necessary to achieve extinguishment. Temperatures, gas concentrations, breakdown products, etc. are to be monitored.

EXPECTED OUTPUT: Since halon 1301 is already being used on vessels for machinery space protection, these tests will determine if the same halon supply can provide cargo protection.

DOT FIRE SAFETY R&D

TITLE: Cargo Hold Extinguishment with Halon 1211

CONTRACT NO.: 3308.5.7

FUNDING LEVEL: $72,100

PERFORMING ORGANIZATION: USCG R&D Center

NAME OF PRINCIPAL INVESTIGATOR: R.C. Richards

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Determine the ability of Halon 1211 to safely extinguish cargo hold fires.

DESCRIPTION OF WORK: Halon 1211 will be applied to large scale cargo hold fires to determine the conditions under which these fires can be extinguished.

EXPECTED OUTPUT: The viability of Halon 1211 extinguishing systems for cargo hold fires will be determined.

DOT FIRE SAFETY R&D

TITLE: Carpet Fire Tests

CONTRACT NO.: MIPR

FUNDING LEVEL: $25,000

PERFORMING ORGANIZATION: National Bureau of Standards

NAME OF PRINCIPAL MONITOR: W. G. Boyce

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Evaluate laboratory fire tests of carpet to determine which, if any, correlate with large fires. Evaluate carpet fire tests requirements for shipboard use.

DESCRIPTION OF WORK: Phase I is a study of shipboard conditions to determine carpet fire test needs.

Phase II is an examination of various tests for ignition, heat release, flame spread, and smoke produced. For example, flame spread tests to be evaluated are ASTM E-84 with both floor and ceiling mounting, UL 992, Flooring Radiant Panel, and a proposed IMCO Test using the ISO apparatus.

EXPECTED OUTPUT: Recommendation of fire tests for carpet installed on ships.

DOT FIRE SAFETY R&D

TITLE: Fire Performance of Intermodal Shipping Containers

CONTRACT NO.: 3308.5.5.4

FUNDING LEVEL: $59,300

PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL INVESTIGATOR: R. Eberly

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Examine the potential fire hazards of intermodal shipping containers.

DESCRIPTION OF WORK: Fires originating within containers were examined to determine if they could burn through the container shell.

The effects of exterior spill fires on a single level of containers and on a stack of containers were examined.

EXPECTED OUTPUT: Interior test fires self-extinguished from oxygen depletion.

Steel containers do not act as a barrier to prevent spread of fire through a container stack.

Wood floorboards do not add to the rapid spread of flame through a container stack.

Aluminum alloy frames do not provide an equivalent amount of structural integrity as steel frames during a fire.

The stacking and lashing fittings currently used provide an adequate amount of structural stability under fire conditions.

DOT FIRE SAFETY R&D

TITLE: Fire Endurance of Aluminum and Steel Hatch covers

CONTRACT NO.: 3308.5.5.1

FUNDING LEVEL: $11,000

PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL INVESTIGATOR: D.E. Beene Jr.

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: To determine if light weight aluminum hatch covers are an acceptable alternative to steel for tank vessels.

DESCRIPTION OF WORK: Five hatch covers were placed in a 1000 square foot fire which burned for 30 minutes. Two were steel and 3 were aluminum. Flame temperatures reached 1922°F. The aluminum hatch covers melted within 17 minutes of ignition while the steel covers remained intact throughout.

EXPECTED OUTPUT:

Aluminum hatch covers are not an acceptable equivalent to steel.

DOT FIRE SAFETY R&D

TITLE: Comparison of combustibility tests.

CONTRACT NO.: MIPR

FUNDING LEVEL: $5000

PERFORMING ORGANIZATION: National Bureau of Standards and Underwriters Laboratories

NAME OF PRINCIPAL MONITOR: Klaus Wahle

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Qualify Underwriters Laboratories to conduct noncombustibility tests using IMCO noncombustibility furnace..

DESCRIPTION OF WORK: Identical samples are to be tested in both the NBS IMCO furnace and a newly constructed UL IMCO furnace to determine if the results are the same.

EXPECTED OUTPUT:

Approval of UL as an acceptable laboratory for compliance testing of noncombustible material.

DOT FIRE SAFETY R&D

TITLE: USCG Cutter Bulkhead Panel Fire Tests

CONTRACT NO.: 3308.5.8

FUNDING LEVEL: $69,700

PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL INVESTIGATOR: C.D. Wolverton

SPONSORING ORGANIZATION: U.S. Coast Guard (G-ENE)

OBJECTIVE: Evaluate the performance of lightweight honeycomb wall panels in full scale burnout tests of shipboard compartments.

DESCRIPTION OF WORK: Mock-up living quarters similar to those found on Coast Guard cutters are to be constructed on a test ship. In lieu of standard noncombustible marinite panels, lightweight panels are to be used. The test will determine how long the panels can be expected to last under realistic shipboard fire conditions and to measure smoke and toxic gases that may be evolved.

EXPECTED OUTPUT:

Data on suitability of lightweight honeycomb panels for use on board Coast Guard cutters where weight is critical.

DOT FIRE SAFETY R&D

TITLE: NAS Fire Safety Aspects of Polymers

CONTRACT NO.: 4-35856

FUNDING LEVEL: $20,000 (Coast Guard share)

PERFORMING ORGANIZATION: National Academy of Sciences

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: USCG, NAS, FAA, FRA

OBJECTIVE:

Study burning characteristics of polymers to improve understanding of the fire safety of these materials.

DESCRIPTION OF WORK:

Identify existing knowledge of combustibility of polymers. Examine the nature of by-products of combustion. Determine how fire behavior of polymers may be measured and predicted.

EXPECTED OUTPUT:

Recommendations to make the use of polymeric materials safe in specific applications.

DOT FIRE SAFETY R&D

TITLE: Commercial Vessel Safety Fire Testing Support

CONTRACT NO.:

FUNDING LEVEL: $150 - $200 K annually

PERFORMING ORGANIZATION: CG R&D Center/Fire and Safety Test Facility

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: U.S.C.G. Office of Merchant Marine Safety

OBJECTIVE: To test, full scale, new materials, agents and methods for commercial vessel fire protection/prevention.

DESCRIPTION OF WORK: Tests are planned by R&D Center personnel and carried out at the Fire & Safety Test Facility, Mobile, Ala. Previous work includes tests of life saving equipment, deck monitors, compatibility of foam/dry chemicals, explosion suppression systems for tanker pumprooms. Future work includes compartment burnout series, cargo hold extinguishment series, drum tests for flammable liquids.

EXPECTED OUTPUT:

Experimental data for use by the Office of Merchant Marine Safety in preparation of regulations.

DOT FIRE SAFETY R&D

TITLE: Study of smoke and heat from fires in vessels.

CONTRACT NO.: MIPR

FUNDING LEVEL: $50,000

PERFORMING ORGANIZATION: National Bureau of standards

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Determine expected smoke and heat from fires involving shipboard materials and predict its spread.

DESCRIPTION OF WORK:
Shipboard materials and arrangements will be examined to determine the quantity of smoke and heat produced by typical fires and how heat and smoke spread through a vessel.

EXPECTED OUTPUT:
Recommendations on controls for ventilation systems and subdivision of vessels.

DOT FIRE SAFETY R&D

TITLE: Cargo Hold Fire Extinguishment Using High Expansion Foam

CONTRACT NO.: 3308.5.5

FUNDING LEVEL: $75,000

PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Determine the ability of high expansion foam to extinguish advanced Class A cargo hold fires.

DESCRIPTION OF WORK: One hold of a cargo vessel will be filled with baled cardboard and ignited. After a suitable preburn to allow the fire to become deep seated, an attempt will be made to extinguish the fire with high expansion foam.

EXPECTED OUTPUT:

If successful, high expansion foam may be allowed as an alternative to the carbon dioxide systems presently required for cargo holds.

DOT FIRE SAFETY R&D

TITLE: Portable Extinguisher Evaluation for CG cutters

CONTRACT NO.: 3308.5.3

FUNDING LEVEL: $48,600

PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL INVESTIGATOR: D. E. Beene, Jr.

SPONSORING ORGANIZATION: U.S. Coast Guard (G-ENE)

OBJECTIVE: Examine market to determine if optimum extinguishers are being used in engine rooms of Coast Guard cutters.

DESCRIPTION OF WORK:
Bilge fires, flowing fires, and spray fires were extinguished using 3 dry chemical, and 2 halon agents. These were compared with the carbon dioxide and dry chemical fire extinguishers presently used in engine rooms of Coast Guard cutters.

EXPECTED OUTPUT:
Halon 1211 was found to be much more effective than CO_2 on a weight basis.

Dry chemical was equal to or better than halon in all cases tested.

Technique proved to be more important than agent.

DOT FIRE SAFETY R&D

TITLE: Port Safety Fire Fighting Requirements Study

CONTRACT NO.: CG-42.355-A

FUNDING LEVEL: $90,000

PERFORMING ORGANIZATION: Applied Technology Corporation

NAME OF PRINCIPAL MONITOR: E. H. Bonekemper III

SPONSORING ORGANIZATION: USCG (G-WLE)

OBJECTIVE:

To evaluate current C.G. fire fighting capability compared to hazards present and, if necessary, provide alternative suggestions to upgrade our level of effectiveness

DESCRIPTION OF WORK:

Define available municipal, industrial and Coast Guard firefighting equipment, personnel and training and compare to maximum potential fire in area. If available resources are not sufficient to effectively combat these fires, provide suggesions to upgrade Coast Guard effectiveness.

EXPECTED OUTPUT:

A series of levels of desirable equipment which would improve CG firefighting. The program manager will be able to select the level of equipment/performance which is commensurate with CG policy.

DOT FIRE SAFETY R&D

TITLE: Flammability of Solids and Liquids

CONTRACT NO.: CG-74142

FUNDING LEVEL: $25,000

PERFORMING ORGANIZATION: U. of Oklahoma

NAME OF PRINCIPAL MONITOR: E. H. Hotard

SPONSORING ORGANIZATION: USCG Office of R&D (G-DSA-1)

OBJECTIVE: Obtain the ignition or "flash" characteristics of liquids and predict the flammable characteristics of solid materials under actual fire conditions utilizing the University of Oklahoma standardized ignition test.

DESCRIPTION OF WORK:
Develop and demonstrate a standardized test for accurately determining the ignition point of liquids and the behavior of flame spread across solids. This will involve constructing a test cabinet and using radiant heat as an ignition source. Flame spread will be measured by thermocouple strings on a test bed.

EXPECTED OUTPUT:

An evaluation of using the developed methods for determining the flash point of liquids and the flame spread characteristics of solids.

DOT FIRE SAFETY R&D

TITLE: Development and Evaluation of International Flame Spread Test

CONTRACT NO.: MIPR

FUNDING LEVEL: $50,000

PERFORMING ORGANIZATION: National Bureau of Standards

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: Evaluate flame spread test proposed by IMCO using ISO apparatus and make recommendations to improve or replace the apparatus.

DESCRIPTION OF WORK:
Tests are being conducted using the proposed flame spread apparatus. These are being compared with tests using flame spread apparatus common in the United States.

EXPECTED OUTPUT:

Several changes to improve the operation of the apparatus have been made. The output may be a single international flame spread apparatus to replace the multitude of tests now being used.

DOT FIRE SAFETY R&D

TITLE: Automated Deck Foam Fire Extinguishing Systems for Tankers

CONTRACT NO.: 3308.5.5.1

FUNDING LEVEL: $91,300

PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL MONITOR: D. F. Sheehan

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MMT)

OBJECTIVE: To determine if unmanned foam monitors can be effectively used as an alternative to manned foam monitors for combating major cargo fires aboard tankers.

DESCRIPTION OF WORK:

Several oscillating, remote controlled, and automatic monitors were tested on large spill fires on the deck of a tankship.

Maneuverability tests were conducted using remote control and automatic monitors to determine response time and ability to aim monitors as desired.

EXPECTED OUTPUT:

Automated monitors are unreliable even under test conditions. In the harsh marine environment their reliability would be unacceptable.

In some cases loss of foam was as high as 25 to 50% due to overshooting or improper aim, even when the fire location was known in advance.

Manual override is needed.

Exposure to personnel is reduced.

DOT FIRE SAFETY R&D

TITLE: Hazardous Materials Advisory Committee

CONTRACT NO.: DOT-CG-74248-A

FUNDING LEVEL: $120,000

PERFORMING ORGANIZATION: National Academy of Sciences

NAME OF PRINCIPAL MONITOR: M. M. Williams

SPONSORING ORGANIZATION: U.S. Coast Guard (G-MHM)

OBJECTIVE: Review and reevaluate the hazardous properties of materials shipped in bulk in Marine transportation.

DESCRIPTION OF WORK:

Initial review and evaluation is bulk water shipments of LNG. Later effort will be directed toward review and evaluation of hazard of other bulk cargoes. This includes emergency response procedures.

EXPECTED OUTPUT: NAS report on LNG expected by 1 January 1979.

DOT FIRE SAFETY R&D

TITLE: Emergency Capabilities for Responding to Marine Hazardous Cargo Casualties.

CONTRACT NO.: # 70099-7-75042

FUNDING LEVEL: $80,000

PERFORMING ORGANIZATION: National Academy of Sciences

NAME OF PRINCIPAL MONITOR: W. D. Markle

SPONSORING ORGANIZATION: USCG, MARAD, U.S. Navy, U.S. Army

OBJECTIVE: Assess the capabilities of responsible government agencies and industries to limit major hazards resulting from casualties to cargo ships or barges carrying bulk quantities of hazardous materials.

DESCRIPTION OF WORK:
Identify the technological deficiencies in:

(1) Preplanning
(2) Response procedures
(3) Equipment needed for fast response

EXPECTED OUTPUT:
Report highlighting both capabilities and deficiencies within the marine community to respond to and limit maritime casualties involving hazardous cargoes. Recommendations for alleviating deficiencies.

DOT FIRE SAFETY R&D

TITLE: Fire Exposure of Polyethylene and Steel Drums Loaded with Flammable Liquids, Phase II

CONTRACT NO.: DOT-A5-60071

FUNDING LEVEL: Funded by MTB

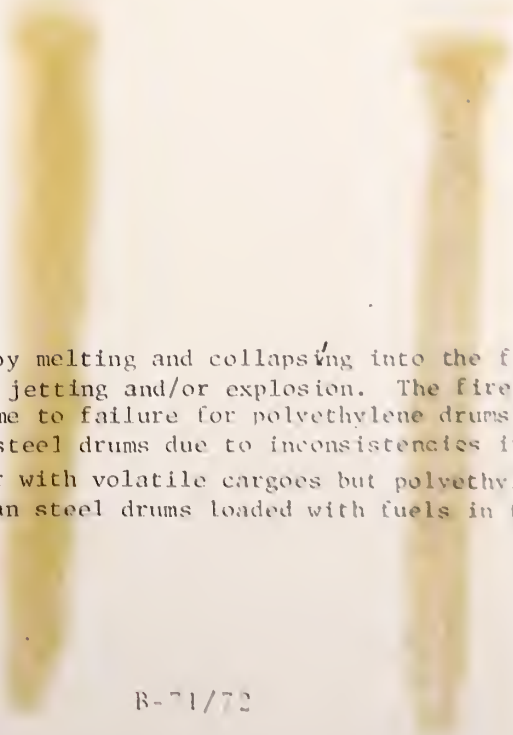
PERFORMING ORGANIZATION: U.S. Coast Guard R&D Center

NAME OF PRINCIPAL INVESTIGATOR: R. C. Richards

SPONSORING ORGANIZATION: Materials Transportation Bureau

OBJECTIVE: Compare the resistance of steel and polyethylene drums to fire exposure.

DESCRIPTION OF WORK:
Fire exposures varied from 90 sq. ft. fires completely engulfing the drum to 25 sq. ft. fires exposed to one side of the drum. Lubricating oil, JP-4, and ethyl ether were tested to examine effects of cargo volatility. Pressure, internal & external temperature, time to failure and mode of failure were recorded. These tests were based upon previous tests reported in Coast Guard report CG-D-116-76.



EXPECTED OUTPUT:
Polyethylene drums fail by melting and collapsing into the fire. Steel drums fail catastrophically by jetting and/or explosion. The fire size had no significant effect on time to failure for polyethylene drums and no relationship could be determined for steel drums due to inconsistencies in manufacturing. Failure times are similar with volatile cargoes but polyethylene drums fail 3 to 4 minutes sooner than steel drums loaded with fuels in the volatility range of JP-4 or lower.

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